Complementing the Latest APA Definition of Hypnosis: Sensory-Motor and Vascular Peculiarities Involved in Hypnotizability

ENRICA L. SANTARCANGELO AND ELIANA SCATTINA

University of Pisa, Italy

Abstract: The aim of this article is to complement the recently revised American Psychological Association (APA) definition of hypnotizability. It (a) lists a few differences in sensorimotor integration between subjects with high (highs) and low (lows) hypnotizability scores in the ordinary state of consciousness and in the absence of suggestions, (b) proposes that hypnotizability-related cerebellar peculiarities may account for them, (c) suggests that the cerebellum could also be involved in cognitive aspects of hypnotizability and (d) explains why the information derived from studies of sensorimotor and cardiovascular aspects of hypnotizability may be relevant to its definition and useful in orienting further experimental research in the field of hypnosis.

The latest definition of hypnosis proposed by the American Psychological Association (APA) describes hypnotizability as the ability “to experience suggested alterations in physiology, sensations, emotions, thoughts, or behavior during hypnosis” (Elkins, Barabasz, Council, & Spiegel, 2015, p. 6). This description seems to disregard two relevant points: The first is that the suggestions able to modify the listed functions are also effective in the ordinary state of consciousness (Derbyshire, Whalley, & Oakley, 2009; Meyer & Lynn, 2011); the second is that hypnotizability represents much more than a trait facilitating the embodiment of suggestions. In fact, studies performed with participants in their ordinary state of consciousness and in the absence of suggestions have revealed several differences between individuals with high (highs) and low hypnotizability scores (lows) not only in the cortical activity/connectivity (Chiarucci et al., 2014; Cojan, Piguet, & Vuilleumier, 2015; Hoeft et al., 2012; Madeo, Castellani, Santarcangelo, & Mocenni, 2013; McGeown, Mazzoni, Vannucci, & Venneri, 2015) but
also in sensorimotor integration (Menzocchi, Mecacci, Zeppi, Carli, & Santarcangelo, 2015; Santarcangelo, 2014) and cardiovascular control (Jambrik et al., 2005; Jambrik, Santarcangelo, Ghelarducci, Picano, & Sebastiani, 2004; Santarcangelo et al., 2012).

We focused our research on the somatic and autonomic correlates of hypnotizability from the very beginning of our research in the field of hypnosis. In an evolutionary perspective, we considered it unlikely that an individual characteristic heavily based on brain circuits designated to several functions (Cojan et al., 2015; Hoeft et al., 2012) can influence only one kind of behavior, that is, the proneness to accept suggestions (Barabasz et al., 1999; Green, Barabasz, Barrett, & Montgomery, 2005). In addition, the low percentage of subjects with high scores of hypnotizability in the general population (Balthazard & Woody, 1989; Carvalho, 2013; Carvalho, Kirsch, Mazzoni, & Leal, 2008; De Pascalis, Bellusci, & Russo, 2000; De Pascalis, Russo, & Marucci, 2000) suggested that this trait may represent an evolutionary disadvantage, the nature of which was still unknown.

We are aware that exploring the role of hypnotizability out of the circumscribed field of the response to suggestions may be considered not necessary to its definition in the field of hypnosis. However, with the aim to show that this is not entirely correct, we summarize here a few findings indicating that the cerebellum plays a role in the highs’ peculiarities in sensorimotor integration, supporting the hypothesis that the cerebellum may take part in both the sensorimotor and cognitive aspects of hypnotizability, and suggesting a molecular mechanism possibly responsible for the highs’ cerebellar peculiarities.

**SENSORIMOTOR INTEGRATION**

In the absence of suggestions, nonhypnotized highs and lows differ in the following:

1. **Posture and Locomotion Control.** During visual and leg proprioceptive alteration, the highs’ body sway is larger and faster than the lows’ and it does not become slower and smaller over consecutive trials (Santarcangelo, Scattina, Carli, Macerata, & Manzoni, 2008). Stabilogram diffusion analysis (Collins & De Luca, 1993) shows that the highs’ postural control is less strict and mainly centrally driven. In addition, modulation of the neck proprioceptive input induced by head rotation influences the highs’ postural and locomotion control less than the lows’ (Menzocchi et al., 2010; Santarcangelo et al., 2008), indicating less ability to integrate the neck proprioceptive information. Sensorimotor adaptation involves a gradual updating of forward models and extensive evidence supports a role for cerebellar thalamo-cortical
pathways in this process (Galea, Vazquez, Pasricha, De Xivry, & Celnik, 2011; Imamizu, Kuroda, Miyachi, Yoshioka, & Kawato, 2003; Imamizu et al., 2000; Tseng, Diedrichsen, Krakauer, Shadmehr, & Bastian, 2007). Alteration of this cerebellum-dependent process may account for less strict postural and locomotion control. Different mechanisms should be involved in the hypnotizability-related difference earlier observed in spinal reflexes (Santarcangelo, Busse, & Carli, 1989, 2003).

2. **Visuomotor Performance.** When asked to launch small wood balls toward a target (Martin, Keating, Goodkin, Bastian, & Thach, 1996a, 1996b), the highs’ performance is significantly less accurate and more variable than the lows’ and does not improve over consecutive trials (Menzocchi et al., 2015).

In this classic visuomotor task, highs behave like children suffering with developmental coordination disorder (DCD) who exhibit poor throwing accuracy and loose postural control. DCD is associated with greater activation in frontal, parietal, and temporal brain regions and reduced activation of areas involved in motor control, motor learning, and error processing and is considered a consequence of delayed cerebellar development (Zwicker, Missiuna, Harris, & Boyd, 2012).

3. **Blink Rate.** The findings on spontaneous blink rate—a correlate of the attentional state—in highs and lows in resting conditions are not consistent, likely owing to differences in the individual level of arousal and/or to the enrollment of different subtypes of highs (Terhune, 2015). We found higher blink rate in highs than in lows and mediums (Di Gruttola, Orsini, Carboncini, Rossi, & Santarcangelo, 2014). Theoretically, this could depend on higher dopaminergic tone in their blinking neural circuit (Blinn, Masson, Azulay, Fondarai, & Serratrice, 1990; Karson, 1983; Taylor et al., 1999), which has been hypothesized but never demonstrated (Bryant, Hung, Dobson-Stone, & Schofield, 2013; Presciuttini et al., 2014).

Indeed, lower efficacy of the inhibitory control exerted by the cerebellum on frontal and occipital cortical areas induces a higher blink rate (Gerwig, Kolb, & Timmann, 2007; Karson, 1983) and mimics the effects of higher dopaminergic tone.

4. **Cerebellar Control of Pain.** The cerebellum exerts inhibitory pain control. After cerebellar anodal direct transcranial stimulation (tDCS), the general population undergoing nociceptive stimulation reports reduced pain and shows smaller laser-evoked potentials (LEPs) amplitudes most likely due to enhanced inhibitory activity of the Purkinje cells on cerebellar nuclei (Bocci et al., 2016; Galea, Jayaram, Ajagbe, & Celnik, 2009; Priori, Ciocca, Parazzini, Vergari, & Ferrucci, 2014). In contrast, highs report significantly increased pain and show significantly larger LEPs (Bocci et al., 2016). Thus, in highs, cerebellar anodal tDCS seems to depolarize cerebellar nuclei rather than the cerebellar cortex, which could be accounted for by structural cerebellar peculiarities presently under investigation.
POSSIBLE MECHANISMS OF CEREBELLAR-ALTERED FUNCTION

In the general population, the diameter of an artery disoccluded after a 5-minute long occlusion is larger than before the occlusion (Resnick et al., 2003). Such a diameter increase (endothelial function) is due to the release of nitric oxide (NO) by endothelial cells promoted by the shear stress associated with blood flow (postocclusion, flow-mediated dilation [FMD]).

During cognitive stress (Jambrik et al., 2004) and nociceptive stimulation (Jambrik et al., 2005), highs do not exhibit the reduction in the brachial artery FMD (endothelial dysfunction) that occurs in the general population in these conditions.

NO is generated from arginine by a family of three distinct calmodulin-dependent NO synthase (NOS) enzymes: NOS from endothelial cells (eNOS) and neurons (nNOS) are constitutively expressed, while expression inducible NOS (iNOS) requires transcriptional activation mediated by cytokines (Resnick et al., 2003). eNOS is mainly responsible for smooth muscle relaxation and nNOS for neuronal signaling; yet, both eNOS and nNOS are represented in endothelial cells, and eNOS and nNOS exert a cooperative role in the control of heart contractility (Loyer, Heymes, & Samuel, 2008) and in protecting the heart against myocardial infarction (Nakata et al., 2008). Additionally, eNOS-derived NO in the nucleus tractus solitarii plays a major role in the control of baroreflex gain and arterial pressure through vascular-neuronal signaling (Paton, Waki, Abdala, Dickinson, & Kasparov, 2007) and/or the modulation of the interaction between astrocytes and neurons (Lin, Taktakishvili, & Talman, 2007). In the whole brain, eNOS-derived NO, after diffusion to the extracellular compartment, can act in cooperation with nNOS-derived NO.

NO is largely represented in the brain and particularly in the cerebellum. Exaggerated NO availability is detrimental for cerebellar development (Contestabile, 2012) mainly because it alters the regulation of granules maturation and, consequently, the inhibitory activity of Purkinje cells (Wang et al., 2014).

Further research should assess whether impaired maturation of cerebellar cells occurs in highs owing to unregulated endothelial NO availability in the cerebellum vessels.

CEREBELLUM-DEPENDENT HYPNOTIZABILITY?

Cerebellar and cerebral areas are coactivated during a wide range of cognitive tasks (Balsters, Laird, Fox, & Eickhoff, 2014). Several studies
using functional magnetic resonance imaging (fMRI) have reported functional connectivity between the cerebellum and cerebral networks involving both motor and cognitive functions (Bernard et al., 2014, 2012; Buckner, Krienen, Castellanos, Diaz, & Yeo, 2011; Sang et al., 2012). Further, diffusion tensor imaging-based tractography has provided evidence for white-matter tracts between the dentate nucleus—a major source of cerebellar output—and the prefrontal and parietal areas (Jissendi, Baudry, & Balériaux, 2008; Palesi et al., 2014; Ramnani, 2006), suggesting extensive structural connections between the cerebellum and the associative cerebral cortex in humans. Indeed, the human cerebellum has a number of nonmotor functions, ranging from perception (Baumann et al., 2015) to attention (Brissenden et al., 2015) and emotion (Watson et al., 2013). In particular, the cerebellar connections with the prefrontal cortex suggest that prefrontal-projecting cerebellar lobules (Crus I & Crus II) process rule-based information regardless of whether rules specify actions (Balsters, Whelan, Robertson, & Ramnani, 2013). Cerebellar abnormalities have been observed in several psychiatric disorders (Phillips, Hewedi, Eissa, & Moustafa, 2015) and attention deficits (Kucyi, Hove, Biederman, Van Dijk, & Valera, 2015), while verbal working memory, processing speed, and verbal and visual learning/memory have been found impaired in patients undergoing surgery for cerebellar neoplastic diseases (Moberget et al., 2015).

In the field of hypnosis, a subgroup of highs has shown impaired working memory (Terhune, 2015) and fMRI studies have shown that the report of involuntariness in action is associated with the activation of a parieto-cerebellar network, which differentiates the highs’ cortical activations during hypnotic-suggestions-induced movements reported as involuntary with respect to movements experienced as self-initiated and controlled (Blakemore, Oakley, & Frith, 2003).

Further research should assess whether hypnotizability can be considered one of the nonmotor cerebellar competencies by systematic investigation of cerebellar-dependent cognitive functions. In fact, the cerebellar connections (see Table 1) to the prefrontal and parietal cortex (Allen et al., 2005), which are also involved in hypnotizability (Cojan et al., 2015; Hoeft et al., 2012), suggest that a few cognitive aspects of hypnotizability may be at least partially influenced by the cerebellum.

On these bases, it appears that the hypnotizability-related differences in the sensorimotor and autonomic domain in the ordinary state of consciousness and in the absence of suggestions are important characteristics able to orient research on the nature of hypnotizability toward unexplored fields. Thus, these differences could be worth mentioning in the definition of hypnotizability. In our opinion, the definition should be the following: A physiological trait consisting of peculiar cortical, sensorimotor, and cardiovascular characteristics, associated with the ability
**Table 1**

*Cerebellar Functional Connections to Associative Brain Regions*

<table>
<thead>
<tr>
<th>From</th>
<th>Right DN</th>
<th>Left DN</th>
</tr>
</thead>
<tbody>
<tr>
<td>To subcortical regions</td>
<td>globus pallidus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>putamen</td>
<td></td>
</tr>
<tr>
<td>cerebral cortex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frontal</td>
<td>medial gyrus</td>
<td>medial gyrus</td>
</tr>
<tr>
<td></td>
<td>middle gyrus</td>
<td>middle gyrus</td>
</tr>
<tr>
<td></td>
<td>precentral gyrus</td>
<td></td>
</tr>
<tr>
<td>parietal</td>
<td>superior gyrus</td>
<td>superior gyrus</td>
</tr>
<tr>
<td></td>
<td>supramarginal gyrus</td>
<td>inferior lobule</td>
</tr>
<tr>
<td></td>
<td>precuneus</td>
<td>supramarginal gyrus</td>
</tr>
<tr>
<td>temporal</td>
<td>superior gyrus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>middle gyrus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inferior gyrus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fusiform gyrus</td>
</tr>
<tr>
<td></td>
<td>insula</td>
<td>insula</td>
</tr>
</tbody>
</table>


Note. Crus I and Crus II are the cerebellar regions connected to cerebral associative areas through dentate nuclei (DN).

to alter the subjective experience and (most of) its physiological correlates according to suggestions’ contents.

**CONCLUSION**

The highs’ sensorimotor integration mode indicates lower cerebellar efficiency with respect to lows. This seems a disadvantageous characteristic; although in highly demanding postural conditions (such as when the risk of falling is high), highs do not behave worse than lows (Caratelli, Menzocchi, Carli, Fontani, & Santarcangelo, 2010; Mecacci, Menzocchi, Zeppi, Carli, & Santarcangelo, 2013).

In contrast, highs should be less vulnerable to cardiovascular events (Santarcangelo & Sebastiani, 2004). Their almost unchanged endothelial NO release (Jambrik et al., 2005, 2004) in conditions associated with its reduction in the general population is a favorable prognostic factor in terms of cardiovascular health (Pinter, Horvath, Sarkozi, & Kollai, 2012; Ras, Streppel, Draijer, & Zock, 2013). It is also worth noting that in resting conditions highs exhibit a preeminent parasympathetic control of heart rate (Santarcangelo et al., 2012), which cooperates with their
larger endothelial NO availability in the prevention of cardiovascular events (Pinter et al., 2012).

In brief, an advantageous cardiovascular determinant (larger endothelial NO availability) could sustain a disadvantageous sensorimotor development (lower cerebellar efficiency). In an evolutionary perspective, this poses a few questions: Was the less efficient cerebellar control of upright stance a detrimental evolutionary factor when humans became bipedal? Can we hypothesize that the individuals exhibiting such unfavorable sensorimotor characteristics may have survived as “highs” owing to their lower vulnerability to cardiovascular events?

Lastly, it appears that we should look at the trait of hypnotizability as a factor responsible for part of the physiological variability in the everyday life. In this respect, may we hypothesize that hypnotizability is even more important in fields other than hypnosis? Should we request physicians—neurologists, physiotherapists, cardiologists—include hypnotic assessment in their patients’ clinical assessment?

References


Ergänzung der aktuellsten APA Definition von Hypnose: Sensomotorische und vaskuläre Besonderheiten, die an der Hypnotisierbarkeit beteiligt sind

Enrica L. Santarcangelo und Eliana Scattina

Abstract: Das Ziel dieses Papers ist, die kürzlich von der American Psychological Association revidierte Definition von Hypnotisierbarkeit zu ergänzen. Es führt (a) einige Unterschiede in sensomotorischer Integration zwischen Subjekten mit hohen und niedrigen Hypnotisierbarkeitslevels im allgemeinen Zustand des Bewusstseins und in der Abwesenheit von Suggestionen auf, weist (b) darauf hin, daß Hypnotisierbarkeits-verknüpfte zerebelläre Besonderheiten dazu beitragen könnten, suggeriert (c), daß das Zerebellum auch in kognitiven Aspekten von Hypnotisierbarkeit beteiligt sein könnte und erklärt (d), weshalb die Information, die aus Studien sensomotorischer und kardiovaskulärer Aspekte von Hypnotisierbarkeit herrühren, für die Definition relevant sein könnten und für die Orientierung weiterer experimenteller Forschung im Feld der Hypnose nützlich sein könnte.

Stephanie Reigel, MD

Un complément à la plus récente définition de l’hypnose selon l’APA: les particularités sensorimotrices et vasculaires impliquées dans l’hypnotisabilité

Enrica L. Santarcangelo et Eliana Scattina

Résumé: Cet article vise à compléter la définition de l’hypnotisabilité, révisée récemment par l’American Psychological Association. a) Il dresse d’abord la liste de certaines différences dans l’intégration sensorimotrice entre sujets dont les scores d’hypnotisabilité sont élevés ou bas en état de conscience ordinaire et en l’absence de suggestion; b) il émet l’hypothèse que les particularités cérébelleuses liées à l’hypnotisabilité puissent être responsables de ces différences; c) il suggère que le cervelet pourrait également être impliqué dans les aspects cognitifs de l’hypnotisabilité; d) il explique pourquoi l’information tirée de l’étude des aspects sensorimoteurs et cardiovasculaires de l’hypnotisabilité peut être pertinente pour sa définition et utile dans l’orientation d’autres recherches expérimentales dans le domaine de l’hypnose.

Johanne Raynault
C. Tr. (STIBC)

Completando la definición de hipnosis más reciente de la APA: Peculiaridades sensoriomotoras y vasculares involucradas en la hipnotizabilidad

Enrica L. Santarcangelo y Eliana Scattina

Resumen: El objetivo de este artículo es complementar la reciente definición revisada de hipnotizabilidad de la Asociación Americana de Psicología. En el
presente (a) se hace un listado de algunas diferencias en la integración sensoriomotora entre sujetos con puntuaciones de hipnotizabilidad altas y bajas en un estado ordinario de conciencia y en ausencia de sugerencias; (b) se propone que algunas peculiaridades cerebelares relacionadas con la hipnotizabilidad pudieran explicar estas diferencias; (c) se sugiere que el cerebelo también podría estar involucrado en los aspectos cognitivos de la hipnotizabilidad; y (d) explica por qué la información derivada de investigaciones de los aspectos sensoriomotores y cardiovasculares de la hipnotizabilidad pueden ser relevantes a su definición y útiles para orientar más investigación experimental en el campo de la hipnosis.

Omar Sánchez-Armáss Cappello, PhD  
Autonomous University of San Luis Potosi,  
Mexico