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**Theses of the Doctoral Dissertation:**

**The psychobiology of tingling and other body sensations**

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*Please, now concentrate on a freely chosen body part (e.g. hands, ears, thighs, etc.), with the eyes closed for 10-15 seconds.*

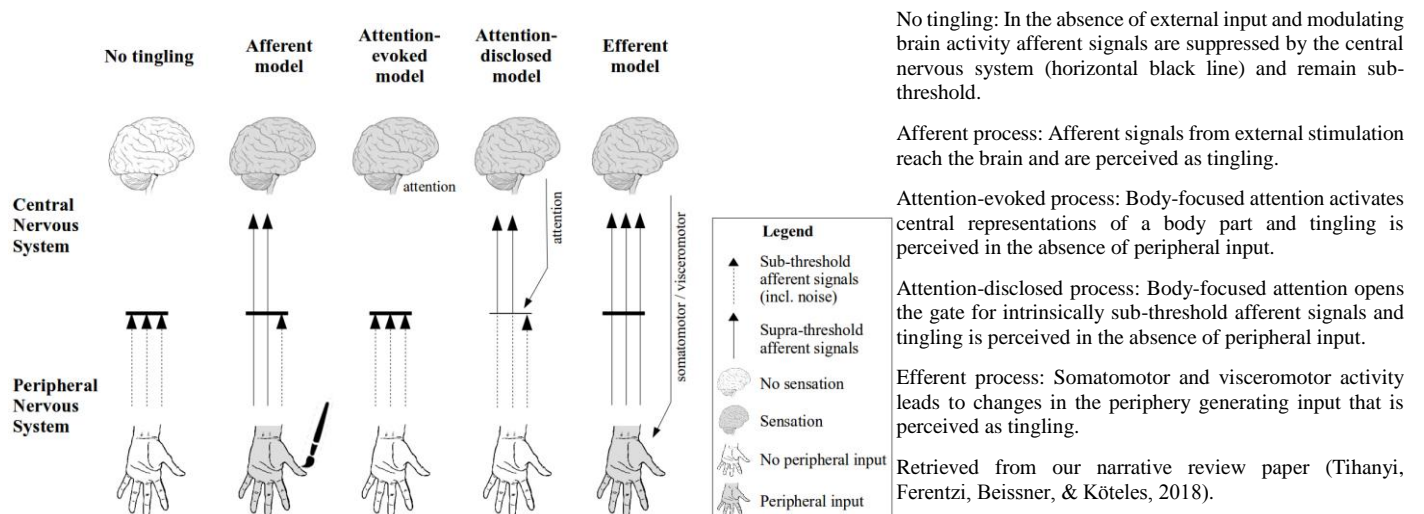
*Has any sensation appeared at that body part while you were paying attention to it?*

Question for attention-related body sensations (ARBS-Qu) developed by Köteles & Tihanyi

**Attention related body sensations (ARBS)** emerge without external stimulation due to focused attention on a body part, especially when the organism is resting (Michael & Naveteur, 2011). ARBS might play a role in numerous important phenomena, positive ones like placebo-effect and 'energy' experiences related to some body-mind techniques (e.g. yoga), as well as negative ones like medically unexplained symptoms and nocebo-effect (Tihanyi, Ferentzi, Beissner, & Köteles, 2018).. The most frequent sensations are tingling, warmth, beat/pulse, cooling, and muscular stiffness. The peripheral origin of all these sensations are easy to understand except the most frequent one: tingling.

**Tingling** is the sensation of many ants walking on your skin. It is one component of the complex sensation we feel after the normal circulation returns to a numb limb, but it is not the pain (needles and pins), nor the unpleasant tension, nor the warmth. Tingling is a bodily sensation experienced under a variety of conditions from everyday experiences to experimental and therapeutic situations (Tihanyi, Ferentzi, Beissner, & Köteles, 2018). It can be induced by both peripheral and afferent (external stimulation, pathology) and higher cognitive (attention, expectation, emotion, bodily self-regulation) processes (see Figure 1.).

1. Figure: The most important characteristics of four possible background processes behind the tingling phenomenon.



**The Introduction** summarizes the current scientific knowledge on the neurophysiological and psychological concomitants of the tingling sensation. Since tingling has not been systematically investigated, there were only fragmented and parallel explanations of its mechanism. These different explanations are described, completed, and also integrated here (Figure 1.).

**General methodological and descriptive results** A standard methodology to examine ARBS was invented and developed, and used in five studies (described later) to explore the psychological and physiological correlates of the phenomenon. The methodological results of the five studies involved in this work showed that ARBS can be investigated not only in real life laboratory situations (ARBS-Test) but also in written questionnaire form, even in on-line setting (ARBS-Qu). The descriptive results showed that roughly half of the participants reported an ARBS, the most frequent sensation was tingling and then warmth. The sensations reported on the ARBS-Qu tended to be rather unintensive, unpleasant, and they appeared ca. 3.5-4 second after starting focusing. The phenomenological analysis identified returning personal explanation of the ARBS, e.g. injuries and diseases even from the remote past, on-going emotions, and the (automatic) activation of skills acquired by learning body-mind technique (e.g. relaxation).

**ARBS and psychophysiological characteristics** were investigated in the following five studies:

*Study #1 'Sports'* involved 1179 adults who filled out the questionnaires, with the main goal to explore the connection between ARBS and sport activity (Tihanyi, Sági, Csala, Tolnai, & Köteles, 2016).

According to the results, ARBS was independent from age and gender, and it was connected to body awareness (the tendency to pay attention to the body), somatosensory amplification (the tendency to label body sensations as unpleasant or harmful), and positive affect. However, the results disproved the hypothesized connection between ARBS and mindfulness (tendency to concentrate on the present experience), negative affect, and physical activity. I also found that the prevalence of ARBS was higher in those who practiced a body-mind oriented technique (yoga, Pilates, kung-fu) than in exercisers of sports not focusing so strongly on the body-mind connection (aerobic, dance).

*Study #2 'Online'* involved 242 adults who filled out the questionnaires on-line with the main goal of explore the connection between ARBS and further subdimension of body awareness (Tihanyi, Ferentzi, Daubenmier, Drew, & Köteles, 2017).

The novelty of Study 'Online' is that it did show the expected positive connection between ARBS and body image dissatisfaction, perceived body symptoms (a construct connected to the tendency of somatization), importance of interoceptive awareness (in decision making), and spirituality.

There was one new hypothesis which was rejected, namely that perceived disconnectedness with the body would be connected negatively with ARBS.

Regarding the hypotheses that were already tested in the previous study, ARBS was connected to body awareness, somatosensory amplification, and experience with a body-mind technique. Study 'Online' showed a positive connection

between ARBS and negative affect while did not reproduce the positive connection with aspects of positive affect. The hypothesized connections with mindfulness and sport were also missing.

**Study #3 'Longi'** involved 69 university students in a longitudinal design, test and retest measurements were separated by 8 weeks (Tihanyi, Ferentzi, & Köteles, 2017).

The answers given to our tools (ARBS-Qu and Test) showed a temporal stability, and also a connection to each other. Another novelty of this study, namely involving Tellegen absorption (i.e. the tendency to become deeply involved in an experience, especially in sensory or emotional ones) and Big Five openness (i.e. an imaginative, curious, and open-minded personality) did not show any positive connection with ARBS.

Body awareness and body image dissatisfaction showed the expected positive connection with ARBS-Qu, while body awareness and somatosensory amplification were connected to ARBS-Test. The other examined variables showed no connection with any of the ARBS scores (perceived body symptoms, mindfulness, importance of interoceptive awareness, perceived disconnectedness from the body, trait positive and negative affect, vitality, spirituality, physical activity, experience with a body-mind technique). Cardioceptive accuracy did not show a connection with ARBS either.

**Study #4 'Students'** involved 94 university students, they filled out the ARBS-Qu together with most of the other previously used questionnaires to replicate the previous findings.

Body awareness, importance of interoceptive awareness (in decision making) and somatosensory amplification showed the expected positive connection. The other examined variables showed no connection with the ARBS-Qu, namely perceived body symptoms, body image dissatisfaction, mindfulness, perceived disconnectedness from the body, trait positive and negative affect, vitality, spirituality, Tellegen absorption, Big Five – openness, hours spent with sport (per week), experience with a body-mind technique.

**Study #5 'Physiology'** involved 27 university students, in order to check the acute physiological changes during ARBS-Test (Tihanyi & Köteles, 2017). Muscle tension was one of the physiological variables that showed a connection with ARBS, namely a negative link with the warmth sensation. A mixed, partly significant negative and partly non-significant connection was found between warmth and local temperature. However, skin conductance, core temperature, and hear rate variability was not connected to warmth, and tingling was not connected to any physiological changes.

**Conclusions:** One thing that can be surely concluded is that the phenomenon of attention-related body sensations (ARBS) exists. Despite the seemingly 'acute' nature of ARBS, some significant connection was found with trait-like mental characteristics, like body awareness. The presence of ARBS was similar to a two-sided coin. From one hand side, it seemed to be connected with somatosensory amplification and frequency of perceived body symptoms. On the other hand, it seemed to be connected to the importance of interoceptive awareness. The cause and consequence of the ARBS reported here could either be positive (e.g. loving the body and relaxing it), or negative (being scared of the body, and becoming tense by the task to pay attention to it), or neutral (simply turning the attention to ongoing bodily processes).

This could contribute to the low statistical power of the results and the some of the controversy, and highlights the importance of the phenomenological exploration of ARBS, which can fill the gap between the mere phenomenon and

standardized psychological questionnaires. Maybe the biggest result of this dissertation is to provide tools to explore the phenomenon of ARBS, not only for face-to-face experimental designs, but also for online written settings. Thus, this dissertation allows future researchers to explore an aspect of body-mind interactions.

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