Eötvös Loránd University, Faculty of Education and Psychology

DOCTORAL (PHD) THESIS BOOKLET

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Self concept, body image, self esteem
The neuropsychological aspect of body representation

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CONTENT

At the turn of the XIXth and XXth century an assumption became widespread, proposing that there probably exists a neural-functional system responsible for bodily awareness. Since then, many attempts have been made to create taxonomy for the different types of body representation (for a review, see de Vignemont, 2010). All of these models provide significant information about the process of body representation, therefore I make an attempt in my thesis to integrate the main proposals of these models. One of the most significant aspect of the systematization of this diverse knowledge is, that body representation is considered a developing process. Thus, the Flowmodel of Body Representation is rather an extension than an alternative of the previous approaches.

THE FLOWMODEL OF BODY REPRESENTATION

In the Flowmodel of body representation in accordance with Gallagher (1986; 2005) we suppose, that our experiences and knowledge about our own body are organized into a complex system, in which the various body represatations create an integrated unit. According to this view, this system is constantly developing, entailing that initially not every single type of body representation exists, and new representations could evolve, moreover the connections between representations could change over time.

Somatosensory inputs from different modalities provide the bases of our knowledge about the body. Information is processed in the cognitive system on different levels: following after perception information could be stored on a basic non declarative level, and subsequently some part of it could become a declarative knowledge.

One possible way of the development of body representation is, that implicit knowledge is recoded through the integration of other (especially visual) modalities, then it becomes a multimodal non declarative, and finally a declarative representation (image or lexical-semantic knowledge). On a declarative level a lexical-semantic knowledge will be added to the existing perceptual and motor experiences. However, there is another way of the development, which involves the conjunction of the different stored information. This „binding” process (see Treisman, 1996, 1998) rather results in conditioned than recoded multimodal body representations. In the following chapter of the thesis, there is a summary of the developmental process of body representation, and a description of the various representations evolving during this process. The flow diagram of the model is presented in the appendix.

SOMATOPERCEPTION

The basis of the body representation is somatoperception. The traditional distinction between on-line and off-line body representations is currently detailed by Longo, Azanon and Haggard (2010). In my understanding it means that there are continous percepts as well as stored representations of the body in the brain. The inputs of the somatoperception come from the following modalities: (1) interoception (proprioception, vestibular system and kinesthetic and visceral information), (2) contactperception (tactile information) and (3) exteroception (e.g. visual information[1]). Some of these modalities could result in continous, on-line body representations. By permanently recieving proprioceptive and vestibular inputs, we are able to percieve our posture in external space, which plays a crucial role in controlling our ongoing motor activity. Following Longo, Azanón and Haggard I refer to this continous dynamic representation as *Postural Body Schema*.

It seems to be also beneficial to constantly process inputs, delivering information about the state of visceral organs, since it is essential for the adaptive functioning of the organs. I label the representation based on on-line perception of inner visceral information as *Visceral Body Schema.*

There is a third significant on-line representation referring to the body, which is the Egocentric Reference Frame of External Space. This representation encodes the external space from a first person perspective, and it integrates

[1] In my thesis I will not discuss the auditory and the olfactory inputs related to the body.

proprioceptive, vestibular and visual information, therefore it can be described – contrary to the aformentioned representations – as „multimodal”. This egocentric spatial reference frame stores information about the relation between the body and the surroundings, thus providing a background for our motor activities.

The on-line perception of information refering to the body, is part of the process called somatoperception (Longo, Azanón & Haggard, 2010). However somatoperception does not only refer to encoding information from proprioceptive and visceral modalities, but also to encoding kinesthetic information. The continous perception of tactile and kinesthetic information is neither necessary nor possible. Although we can assume, that some parts of the occasionally perceived tactile and kinesthetic stimuli might be stored in memory as unimodal somatosensory body representations.

STORED BODY REPRESENTATIONS

The memory model of Squire (2004) provides a theoretical framework, which helps to better understand how stored body representations are organized. This model makes a clear distinction between declarative and non declarative memory system. The declarative memory system encodes facts and events, which can be consciously recalled. The declarative representations can be divided into two major cathegories: images and lexical-semantic representations.

The non declarative memory sytem encodes motor and perceptual experiences. Its specific charachteristic is, that it stores non conscious sensorimotor skills. The distinction between motor and perceptual non declarative representations is supported by the assumption of Dijkerman & de Haan (2007), according to which two separate neural pathways are involved in the processing of somatosensory perception. One of them is responsible for the so called „action”, which refers to the encoding of experiences evoked by motor activity. This neural pathway processes mostly proprioceptive, kinesthetic and vestibular information. The other neural circuit is responsible for the so called „perception”, which refers to the representation of mainly tactile information, which are not related to motor activity.

Non declarative body representations

Tactile stimulation contributes to the representation of the body surface. According to Head and Holmes (1911) we refer to this representation as *Superficial Body Schema*, of which primary function is the localization of tactile stimuli on body surface.

Kinesthetic information keep us about our current motor activities informed. Some elements of this information are also stored in the memory, thus enabling a creation of a representation of the feasible motor functions of the limbs. We refer to this representation as *Representation of the movement possibilities of the extremities*.

These two representations are unimodal, because of being based on a single somatosensory modality. However we propose that on a neurological level information about the body is stored in a cascadic manner (e.g. Marton, 1998). With other words, the basic unimodal representations of the body are recoded at more advanced stages of their development. On these higher levels, body representations are more complex and multimodal, and they integrate different modalities. As a conclusion, their functions – compared to the basic body representations – are more complex, and presumably multiple neural circuits are involved in their functioning.

The „developing” manner of the storage of representation of somatosensory information is in accordance with the anatomical construction of somatosensory system. At the early stages of cortical development, neurons give a specific response based on the characteristics of the stimulus transmitted by peripheral nerves, thus the neural response reflects the characteristics of the matching stimulus. At a higher stage of information processing, neurons have more complex responsible properties, so presumably information from different sources could integrate (Dijkerman & de Haan, 2007).

An example for the recoding of tactile information is the process, in which visual information makes it possible to rescale the superficial body schema. The resulted higher order body representation is responsible not only for lokalization, but also for the perception of the real metric properties of the body (Medina & Coslett, 2010). I will refer to this higher order body representation as *Representation of Real Size of Body Surface*.

The recoding process of vestibular-proprioceptive information enables the development of *Structural Body Schema*, which encodes the topological model of body structure at sensorimotor level (see Sirigu et al, 1991; Buxbaum & Coslett, 2001; Schwoebel & Coslett, 2005).

The most complex representation of the sensorimotor level integrates somatosensory information from different modalities. It connects every perceptual characteristics of the body to the matching information about the possible motor actions (motor commands) (Marton, 1970, 1998, 205). According to Magda Marton (2005) I refer to this sensorimotor body representation as *Visual-Kinesthetic Body Schema*. I suppose that this representation is different from the aforementioned body representations, because the integration of the various information in Visulal-Kinesthetic Body Schema occurs through “binding” (see Treisman, 1996, 1999. After all this representation is rather a conditioned than a recoded multimodal body representation. The Visual-Kinesthetic Body Schema plays an important role in the regulation of voluntary actions, since it provides the basis for the functioning of the internal forward model, which enables one to predict the sensory consequence of a motor activity (l.e.g. Marton, 1970; Wolpert, Ghahramani & Flanagan, 2001; Wolper & Kawato, 1998).

Finally there is another important non declarative body represenation, which evolves also by binding (by conjunction of different bodily experiences). According to Damasio (1994/1996), experiences are encoded in the brain in conjunction with the emotions and the accompanying physiological sings (so called somatic markers) related to the experinces (Somatic Marker Hypothesis). Naturally, emotions may be linked to external events as well as to internal bodily experiences. We consider the representations of emotions and physiological sings related to bodily experiences, the *Somatic Markers of Emotions Related to the Body and Action*, which are the non declarative (conditioned) representation of attitudes towards our own body.

Declarative body representations

On the highest level of the recoding process of the body representation, information is transformed to a general semantic code (lexical representation or image), thus it becomes a symbolic declarative body representation (see Karmiloff-Smith, 1994/1996). Presumably image like and lexical knowledge could be distingushed on the declarative level of body representation, although they could be linked as well. This assumption is supported by the fact, that results of investigations, in which both surveys and visual stimulus based methods were applied, frequently correlate, but entire overlap can not be shown.

Following the terminology used by Banfiled & McCabe (2002) and Keeton, Cash and Brown (1990) I will refer to the kind of declarative body representation, which is based on direct perception but then transformed to a symbolic semantic knowledge, as *Perceptual Body Image*. This body representation involves information about the consciuosly perceived size, shape, structure and weight of the body. It can be considered a system of declarative representations of the own body, which includes both images and lexical-semantic representations.

On the declarative level of the body representation, information based on indirect perception is added to our knowledge about our own body. Our social environment provides general, conceptual and abstract knowledge about the body, that we could not experience by ourseleves. It is a specific encyclopedic knowledge about bodies, e.g. the names of body parts or the topological structure of the body. According to Longo, Azanón & Haggard, (2010) and Slaughter, Heron & Sim (2002) I refer to this body representation as *General Lexical-Semantic Knowledge about Bodies.*

The knowledge about the structure of a human body is represented in the brain on many different levels. On a declarative level it is encoded in both visual and lexical modalities, however followed by an injury these modalities can be affected separately as well (e.g. Body-specific aphasia). We consider the *Represenation of General Shape and Structure of Human Bodies* a declarative image of the body, which might be distinct from both the Perceptual Body Image (representation of the own body) and the *General Lexical-Semantic Knowledge about Bodies*, which are rather lexical representations than images. However we consider these body representations existing separately, they must affect each others' development/functioning significantly.

Finally we distinguish another declarative body representation, which was originally investigated by studying people with eating disorders and received body deformations followed by an accident. The attitudinal component of body representation, in other words the *Attitudinal Body Image* (e.g. Banfield & McCabe, 2002; Keeton, Cash & Brown, 1990), involves the cognitive and emotional attitudes toward the own body. The conscious attitudes toward the body are based on both the introjected evaluations provided by social environment and the subjective evaluation of our own experiences about our own bodies (*Somatic Markers of Emotions Related to the Body and Action)*.

RESEARCH OF THE BODY REPRESENTATION

THE BODY PORTRAYING METHOD

In 2006 we (Verseghi Anna and me) created a novel tool for measuring body representation. The basic idea of the tool is that the shape of the body can be represented by a few typical spots (top of the head, neck, shoulder, armpit, waist, elbow and several spots along the spine) and we can observe how patients portray their bodies using these spots (see **Fig. 1.**).

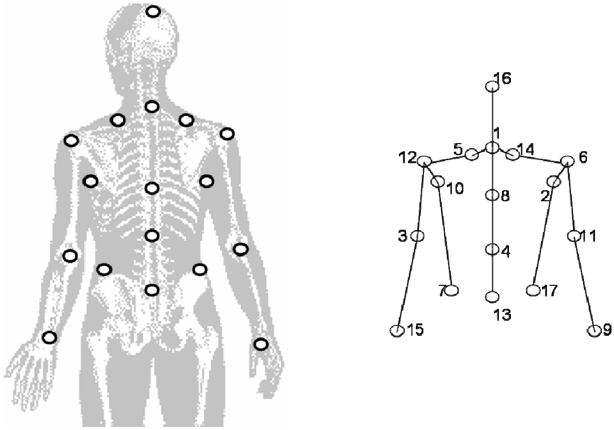

Fig.1. *Schematic portrayal of the body using typical points*
Numbers next to the body spots represent the sequence of portrayal.

During the examination subjects are seated in front of a large sheet of paper (1m x 1.2m) hanging on a wall. We ask them to imagine that they are sitting in front of a mirror. Then the experimenter, standing behind the participants, touches in a strict order different spots on their bodies. The participants had to point with their fingers on the paper the locations of the equivalents of the touched body spots. The experimenter marked these spots and its numbers with a pen. At the end of the portrayal, we ask the subjects to remain still in the same body position, and we record the real position (the perpendicular projections of the touched spots) of the body on the paper.

Variables of Body Portraying

For measuring an overall disruption of body representation we generated a general variable, by taking the mean of the distances (cm) between the portrayed and real positions of each spots of body contour (neck, shoulder, armpit and waist). The bigger value the variable has, the bigger the distruption of the body representation is. However, a general body representation disturbance may have many underlying reasons. It may arise, for instance, from a subjective shift of body location in the horizontal and/or in the vertical dimension, as well as from the disruption of perceived body shape.

Horizontal or vertical shift of body portrayal shows the subjective perception of body location in external space related to its real location. We believe that it would be informative to take into consideration both the extent and the direction of the subjective shifts..

For measuring the subjective shift of body portrayal on x-axis we examine the shift of both the body contour and of the body midline (spinal line). The reason for this is that the body has not only an axis but also a latitude. We suppose that perception of body boundaries might differ from the perception of body axis.

The perception of body shape can dissociate from the perception of body location in external space, especially when the declarative level of body representation (image of body form) sets in during body portrayal. In the examination of the distortion of perceived body shape, independent judges evaluate on a seven-point Likert scale how closely the body portrayals resembled a human upper body.

Although the dissertation does not focus in detail on the body size perception, I believe that the body portrayal method is an appropriate tool for investigating body size estimation as well.

VALIDATION OF THE BODY PORTRAYING METHOD IN HEALTHY POPULATION[2]

The aim of the first investigation of the Body Portraying Method was to validate it in case of healthy subjects. Furthermore we examined the differences between the results of the two different test settings (sitting and standing position). As most brain injured patients are wheelchair bound, they can only be examined in a sitting position. It is a fundamental question, whether portrayal in sitting position is more distorted than in standing position. Another question to investigate is, whether the visual feedback (or the lack of it) has any effect on the quality of the body portrayal?

BODY PORTRAYING WITHOUT VISUAL FEEDBACK

Onehundred and ninety-nine healthy subjects participated in the study; all of them were asked to portray their bodies while they were blindfolded. Otherwise we followed the test procedure exactly as we described it earlier. Onehundred and eight subjects portrayed their bodies while they were standing (standing setting), and ninety-one subjects while they were sitting (sitting setting).

According to the results, there are significant inaccuracies characterizing the body portrayal of healthy subjects. Based on these findings we propose, that the functioning of the body representation system is not completely accurate even among healthy people; and because of this, the Body Portraying Method can also provide relevant information about the quality of the functioning of their body representation system.

The common inaccuracy in body portrayal may arise from a subjective shift of body location in the horizontal and/or in the vertical dimension. Our results show, that during the body portrayal process significant horizontal and vertical shifts of the perceived body location in external space might occur. However the extent of the shift of body portrayal is bigger on y axis than on x axis in

[2] This work has been supported by National Scientific Research Fund (OTKA) No K-81641. Head leader of the research is Anikó Kónya

both sitting and standing position. Our results also indicate, that the there is only a minor correlation between horizontal and vertical shifts (r_s=0,25). Based on our findings we suppose that the representation of the body in the horizontal and vertical dimensions might be at least partially dissociated.

We investigated not only the extent but also the direction of the shift of body portrayal. According to our findings, subjective shifts of body portrayal of healthy subjects occur towards both directions in the horizontal and in the vertical dimensions (leftward-rigthward, upwards-downwards). The investigation of the horizontal shift indicates that the probability of the left and right shifts is balanced within the group of healthy person. However subjects were prone to portray their bodies with an upwards shift in vertical dimension.

Inaccuracy of the body portrayal derives not only from the subjective shift of body location in external space, but also from the distortion of perceived body shape. Our results indicate, that there is a normal distribution regarding the quality of body shape portrayal in healthy population. The mean of the distribution is 3,44 on a seven point likert scale, and the standard deviation is 1. Thus we propose, the the body shape variable of the Body Portraing Method could be applied to measure body representation of healthy subjects.

Comparing the results of the portrayals between the sitting and the standing settings we came to the conclusion, that the posture has a primary effect on the vertical dimension of body portrayal. There was a significant difference between the accuracy of body portrayal in different body positions: it was more inaccurate while subjects were sitting than standing. However results of further analyses show that the difference is caused mainly by the higher extent of the vertical shift, which occurs during body portrayal in sitting position. As a conclusion, it is adviced to instruct normal subjects to remain seated during the body portrayal process, especially if our final goal is to compare the body portrayals of brain injured patients between the members of a healthy population.

In the end we have not found gender differences in body portrayal, and the age had no effect on the performance of healthy subjects either.

THE EFFECT OF THE VISUAL FEEDBACK ON BODY PORTRAYAL

Sixty-eight healthy subjects participated in the study, which was aimed to investigate how the visual feedback can affect the performance of body portrayal. Participants portrayed their bodies first blinfolded, then the blindfolds were removed for a second trial.

As we mentioned before, execution of body portrayal can activate many elements of the representation system. However we suppose that different elements of the system may come into action depending on the access to visual feedback during body portrayal. In blindfolded setting the portrayal is based solely on sensorimotor information, which refers to the activation of non declarative level of body representation. Visual information can augment the sensorimotor information about our body with the sight of size and shape of the body and with signs of directions. Thus we suppose that the open eyed body portrayal also activates the mental images of the body. Therefore we propose that there might be differences between the performance of body portrayal in blindfolded and open eyed settings.

We found it surprising that visual feedback decreased the accuracy of the body portrayal. We developed an explanation for this by analyzing the direction of the shifts. According to our results, the horizontal shifts were decreased if visual feedback was available, whereas subjects portrayed their bodies with bigger vertical shift in open eyed setting than when they were blindfolded. These results – in accordance with our previous study – indicate, that from a first person perspective vertical and horizontal mental representations of the space could dissociate.

We suppose, that the general variable of the Body Portraying Method provide information about the quaility of functioning of the entire body representation system. Whereas the „subvariables” (variables of horizontal and vertical shifts, and variable of body form) can only be related to certain elements of the body representation system. Our results seem to support these previous statements. The subvariables of the body portrayal correlate with each other on a medium level in blindfoded setting. The reason for this might be that the blindfolded portrayal activates the non declarative level of the body representation system, which contributes to the task as a solid unit. However, we did not find any correlations between the subvariables during the open eyed body portrayal. One explanation for these findings can be that open eyed body portrayal also activates the declarative level of the body representation system. In this case, the mental image of the body form (which can be both a general form of the human body or the shape of our own bodies) can also play an important role in the portrayal. This mental image of the body can affect the quality of the portrayal of body form, which is also supported by our results: the quality of the body form during open eyed portrayal is significantly better, than during blindfolded portrayal. Whereas this image-like representation of the body shape does not affect the spatial location of the body in the portrayal. This is rather influenced by the procedural sensorimotor level of body representation, and the visual perception of directions, which dissociates from the visual perception of shapes and forms (see e.g. Csathó, 2008; Verseghi és S.Nagy, 2011). Thus in the open eyed setting, the portrayal of the body shape may partially dissociate from the portrayal of body location (see table 1/a and 1/b).

Table 1/a. Correaltions between the investigated variables in blindfolded setting of body portrayal

Variables	**1.**	**2.**	**3.**	**4.**
1. General inaccuracy				
2. Extent of the horizontal shift of body contour	0,751**			
3. Extent of the horizontal shift of spinal line	0,355**	0,585**		
4. Extent of the vertical shift of body contour	0,820**	0,278*	0,048	
5. Quality of body form	-0,353**	-0,326**	-0,291*	-0,187

N=68. Pearson coefficients of correlation are presented int he table.
Levels of signficance: **: p<0,01, a *: p<0,05; $^{+}$: p<0,1

Table 1/b. Correaltions between the investigated variables in open eyed setting of body portrayal

Variables	1.	2.	3.	4.
1. General inaccuracy				
2. Extent of the horizontal shift of body contour	0,238^{+}			
3. Extent of the horizontal shift of spinal line	-0,095	0,069		
4. Extent of the vertical shift of body contour	0,874**	-0,052	-0,151	
5. Quality of body form	-0,328**	-0,266*	-0,059	-0,149

N=68. Pearson coefficients of correlation are presented int he table.
Levels of signficance: **: p<0,01, a *: p<0,05; $^{+}$: p<0,1

BODY REPRESENTATION AND MOTOR COMPETENCE

The instrument of the movement is the body. Representations of bodily experiences provide basis for the regulation of motor activity. Along with de Vignemont (2010) and Wolpert, Ghahramani és Flanagan (2001) we also suppose that the entire body representation system is involved in the complex process of movement regulation. However, the relation between body representation and motor action seems to be bilateral. We suppose, that on one hand the developmental state of the body representation system has an effect on the level of execution of motor actions, on the other hand, perception of movement is the main source of experiments associated with body (e.g. Gallese és Sinigaglia, 2010; Ivanenko és mtsai, 2011). Therefore representation of the body and regulation of motor actions are inseparable processes, and there is a continuous dinamic interaction between them. In this study we investigated these assumptions and we compared the funcional level of the body representation system to the motor competence and to the frequency of sport activities[3].

[3] This work has been supported by National Scientific Research Fund (OTKA) No K-81641. Head leader of the research is Anikó Kónya

Investigation:

Sixty-eight healthy subjects participated in the study. First we measured the functional level of body representation with Body Portraying Method in both blindfolded and open eyed settings, then we assessed the capacity of dinamic postural control (motor competence) with a device which is generally called a stabilometer. During the task participants are standing on a balance bord, which is connected to a computer and they are trying to move an object on a path by gently locating the center of gravity (by swinging movement) of their bodies. We defined movement efficiency by measuring how much the object moved till it reached its' destination. The less movement it takes the object to reach its goal, the less swinging movement the participant had to do. In this task there were three diferrent paths: circle shaped, slalom from left to right and slalom from right to left shaped. We summarized the distances have been made in all the three different tasks.

According to our results, the frequency of motor activitites has a significant effect (with medium effect size) on the quality of blindfolded body portraying, but it does not influence the level of open eyed body portraying. Consequently, the quantity of motor experiencies might have an affect on the procedural level of body representation system.

Our results also support the assumption, that sport has a positive effect (with high effect size) on motor competence as well.

In accordance with our findings motor competence was associated only with the quality of the open eyed body portrayal. That means, that higher accuracy on open eyed body portraying correlated with better performance in stabilometry (r=0,29). Whereas we did not find relation between blindfolded body portrayal and motor competence. One explanation for this might be, that we measured motor competence with efficiency of open eyed motor actions.

Blindfolded body portrayal was associated with open eyed body portrayal (r=0,428). Consequently our results support the relation between representation of the body and the movement, however our results also indicate, that the two levels of body representation (procedural and declarative) are involved in the regulation of motors actions in a different way. We summarized the dinamic interactive relation between movement and body representation in a diagram presented in Fig. 2.

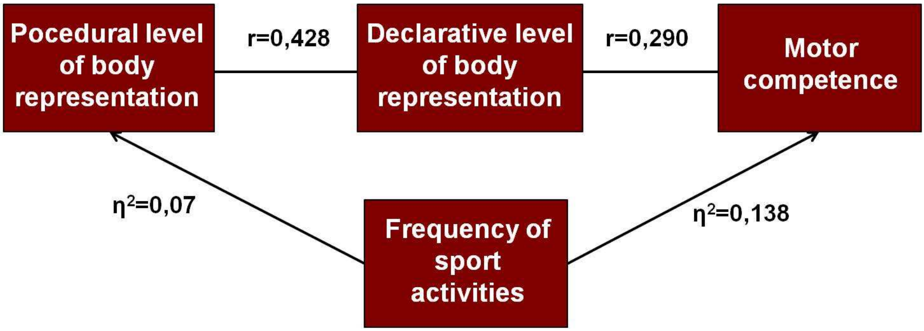

Fig. 2. *Diagram of the relations between body representation and movement*

INTERPRETATION OF THE ASSOCIATIONS BETWEEN SELF-ESTEEM AND BODY REPRESENTATION IN ACCORDANCE WITH THE DEVELOPMENT OF SELF-AWARENESS

In this pilot study we discuss the association between the body representation and self-esteem within the context of self development. Our aim was to confirm the hypotheses, according to which there is a deep connection between our sense of self-esteem and the perception of our body. This connection does not only exist between the sense of self-esteem and the declarative body image but also between the sense of self-esteem and the procedural sensorimotor reperesentation of the body.

In accordance with V.Komlósi (2007), Rogers (1951/1980) and White (1959/1988) we also suppose, that a more differentiated body representation system (which fits more accurately to the reality) enables one to construct a motor plan, that represents better ones' intentions. A more accurate motor plan enhances the overlap between the willed and the actually perceived consequences of the executed actions, wich might raise the sense of competence. Higher sense of competence enables a higher level of adaptation. The organismic assessment processes give positive value to the efficient execution of motor actions, which might results in higher level of self-esteem.

In our pilot study (N=38) we compared the functioning of the non-declarative level of body representation system measured by Body Portraying Method in blindfolded setting with the basic self-esteem, evaluated by Rosenberg Self Esteem Scale. We found a robust correlation (r=0,441; p=0,006) between the level of self-esteem and the quality of body portrayal. According to our interpretation one possible mediator between self-esteem and body representation might be the sense of motor competence. This proposal is supported by our results presented before, which indicates the association of motor competence and body representation.

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BODY REPRESENTATION AND THE NEGLECT SYNDROME

Unilateral neglect is defined as a “failure to report, respond, or orient to novel or meaningful stimuli presented to the side opposite the brain lesion when this failure cannot be attributed to either sensory or motor defects” (Heilman, Watson, & Valenstein, 1993, p. 268). Patients with neglect leave the contralesional half of the space out of consideration, however their primary perceptual processes are intact. These symptoms are usually present when the right hemisphere is damaged, and the term itself refers to the negligence of the left side of the space. Neglect could affect personal (own body) or extrapersonal space (environment perceived visually and auditory), or both of them at the same time.

There are various symptoms of neglect, which are associated with the body. We suggest that these symptoms can be understood as disruptions of different bodily functions (sensation, perception, localization, perception of location of the body in space). In **Table 2.** we summarized some of the well known symptoms of neglect and the related bodily functions, whose damage may cause these symptoms

Table 2. *Functions injured in neglect associated with body*

Neglect specific symptoms	Injured functions related to the body
Ignoring stimulations on the contralesional body half (e.g. Kerkhoff, 2001, Guariglia &Antonucci, 1992)	*The processing of somatosensation* (Longo, Azanón & Haggard, 2010)
Tactile extinction (Wortis, Bender & Teuber, 1948)	
Allochiria: *Alloesthesia*: (Meador, Allen, Adams & Loring, 1991)	*The localization of stimuli on the body surface* (Head & Holmes, 1911)
Subjective shift of own body-midline to the ipsilesional side in external space (Heilman, Bowers & Watson 1983	*Perception of body location in external space* (Head & Holmes, 1911)
A horizontal shift to the ipsilesional side in strait ahead orientation (Ferber, Karnath, 1999,)	*Egocentric spatial orientation in external space*
Motor neglect (Laplane & Degos, 1983)	*Guidance of action* (Paillard, 2005; Dijkerman & de Haan, 2007)
Non-consciousness of the contralesional half of the own body (e.g. Bischiach, Perani, Vallar & Berti, 1986)	*Consciousness of own body* (Head & Holmes, 1911; Longo, Azanón & Haggard, 2010)
Difficulties in drawing a person or in reconstructing body using pre-cut puzzle pieses (e.g Guariglia & Antonucci, 1992)	*Semantic knowledge about arrangement of body parts* (Longo, Azanón & Haggard, 2010)

SHIFTED BODY LOCATION IN NEGLECT

Our pilot study is based on the hypothesis, according to which patients with neglect perceive the midline of their body with an ipsilateral shift (Heilman, Bowers és Watson, 1983), furthermore when they evaluate a subjective straight ahead orientation, a horizontal shift to the ipsilesional side appears (Ferber és Karnath, 1999). We investigated, whether a subjective ipsilateral shift characterizes the portrayal of the whole body or solely the spinal line in case of patietn with extrapersonal neglect.

Twenty patients participated in our study. Ten patients had right hemisphere lesions with left extrapersonal neglect (N+), ten patients had left hemisphere lesions without extrapersonal neglect (N–). We compared the body portrayal of these two groups of patients. Our results show, that patients with neglect portrayed their whole bodies with a significant right (ipsilateral) shift in both (blindfolded and open eyed) settings. Whereas in case of N– patients the horizontal shifts of body location was nonsignificant in open eyed settings, however they portrayed their bodies with a significant shift to the left.

In our interpretation, shifted body portrayal in external space is a disturbance of the Egocentric Reference Frame of External Space. Furthermore the ipsilateral deviation of the Egocentric Reference Frame of External Space seems to be a specific sympotm of neglect.

MULTIPLE DISRUPTION OF BODY REPRESENTATION IN NEGLECT[4]

As we have already suggested, neglect associated with the body can be considered a disturbance of the body represetentation. We also suggest that various symptoms of neglect related to the body can be understood as disruptions of certain levels of the body representation system. In this study we investigated both the representation of egocentric reference and the accuracy of

[4] This work has been supported by National Scientific Research Fund (OTKA) No. K-81641. Head leader of the research: Kónya Anikó

perception of the body form as well According to some studies these two body representations might be represented separately in the brain (Medina & Coslett, 2010; Longo Azanón & Haggard, 2010). Thus, we could expect to find dissociation – even double dissociation – between the disruption of evaluated body location and the distortion of perceived body shape.

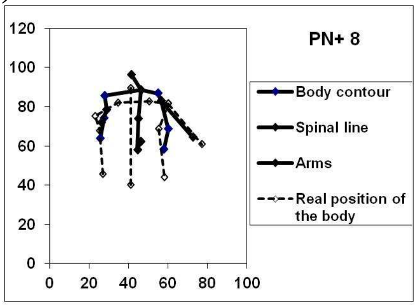
Twenty right-handed patients with subacute brain injury (mean time since brain injury: 87.11 days) and ten right-handed healthy control subjects participated in the study. Ten patients had right hemisphere lesions with left extrapersonal neglect (PN+), ten patients had left hemisphere lesions without extrapersonal neglect (PN–). We compared the quality of body portrayal of these groups.

Similarly to our previous study, patients with neglect portrayed their whole bodies with a significant right (ipsilateral) shift in both (blindfolded and open eyed) settings. In case of PN- patients and healthy controls the horizontal shift was nonsignificant in open eyed setting. Our results also indicate that in blindfolded setting not only patients with neglect but also healthy controls and patients without neglect might perceive their bodies with a significant horizontal shift. However, the shift directs typically rightwards in case of patients with neglect contrary to patients without neglect and healthy controls, who tend to perceive their bodies with a subjective left shift.

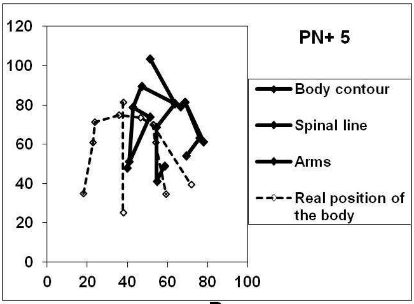
Considering the *perception of body shape*, our results show that patients with neglect portray their bodies with a significantly more distorted shape than patients without neglect or healthy controls. Furthermore the difference between patients without neglect and controls was non-significant.

According to our results, both the shift of body location to the right and the distortion of perceived body shape occurred only in case of patients with neglect. However case statistics within PN+ group show, that disturbance of body representation might dissociate from extrapersonal neglect. According to our results, at least one of the examined symptoms of body representation disturbace occurred in the majority of patients with neglect, but several PN+ patients portayed their bodies neither with horizontal shift nor with distorted body shape. These results support studies that suggest, that the neglect related to the body might dissociate from extrapersonal neglect.

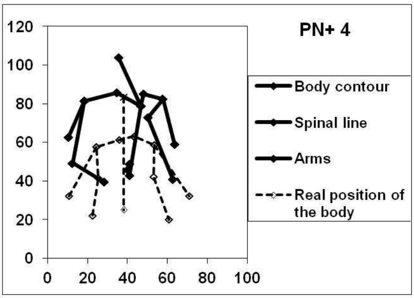
Further case statistics within PN+ group showed, that disruption of egocentric spatial reference frame might dissociate from distortion of body shape in both settings (blindfolded and open eyed) of body portrayal (*Fig. 3*. shows examples for this phenomenon)



A



B



C

Fig. 3. *Dissociation between disruption of body shape and subjective horizontal shift of own body to the right in the group of patients with neglect*

The distorted portrayal of body shape and the perception of shifted body location may appear either separately or together. Panel **A** shows a body portrayal with neither shape distortion and nor shifted body location compared to healthy controls. (Shape distortion score: 3.7; p>0.1; Shift: 0.75 cm; p>0.1) Panel **B** shows a body portrayal with both distorted body shape and shifted body location compared to healthy controls (Shape distortion score: 6.3; p<0.001; Shift: 18.58 cm; p<0.001). Panel **C** shows a body portrayal with distorted body shape, but without shifted body location compared to healthy controls (Shape distortion score: 5.4; p<0.001; Shift: -0.81 cm, p>0.1). The right side of the body portrayal represents the right half of the subject’s body. Solid lines show the body portrayal created by the subject; broken lines show the real position and shape of the subject's body.

We believe that these kinds of investigations are important because they might have practical consequences It is known that patients with neglect are more severely disabled in all daily activities and have poorer rehabilitation outcome than patients without neglect. Presumably, tailored treatment strategies might enhance the effectiveness of rehabilitation. We suggest that injury of different functions might need different treatment strategies. Disruption of body location, for instance, might be treated by movement exercises in external space (e.g. passing by objects). On the other hand, various forms of sensory stimulation of the body surface (e.g. electric stimulation or massage) might improve perception of body surface, thus the perception of body shape. Accordingly, a revealing characteristic of the disturbance of body representation might be an important aspect in the development of individual treatment strategies for the rehabilitation of patients with hemispatial neglect.

SUMMARY

The subject of my thesis is excessively complex. In my opinion, the nature of body representation should be an important research topic, because in my clinical practice I work with patients who are trying to regain their motor abilities during the rehabilitation process. Therefore understanding the process of body representation directly affects my work, by enabling me to more consciously construct the right therapeutic treatment, and additionally it also provides a theoretical challange. The Flowmodell of Body Representation provides a continuously developing theorethical framework for the differentiated explanation for every phenomenon that occurs in relation to the body representation. This model is dinamic, system-oriented, and takes the process-like charecteristic of body representation into consideration. It correspondes with the widely accepted theory of memory, which differentiates between two separate ways of experience: the declarative and the nondeclarative form of learning. However one limitation of the model is that the nondeclarative level of body representation is more elaborated, than the declarative level. The reason for this is, that as a neuropsychologist both in my

research and in my clinical practice I am primarily engaged to the nondeclarative level of body representation

In my thesis I presented a novel method, (Body Portrayal Method) which seems to be an adequate tool for helping us to better understand how the body representation system generally functions. This is a nonverbal method, and it is suitable for measuring the nondeclarative level of body representation system, therefore it is well adaptable for neuropsychological investigations.

Besides all the other empiric research we made, I personally attach great importance to investigations made on patients with brain injuries. In my dissertation I provided a novel theorethical framework for the neglect associated with personal space (body). I proposed, that various symptoms of neglect related to the body can be considered disturbances of the different elements of body representation system. Our findings unequivocally support, that ipsilesional horizontal shift of body location and distroted perception of body shape are specific charachteristics of disturbance of the body representation system of patients with neglect. According to Ferber and Karnath (1999), the ipsilateral horizontal shift of body location might be the result of deviation of egocentric reference frame. This could possibly set the direction for our future investigations.

REFERENCES

Askevold, F. (1975): Measuring body image: Preliminary report on a new method. *Psychoterapy and Psychosomatics, 26(2).* 71–77.

Banfield, S.S., McCabe, M.P. (2002): An evaluation of the construct of body image. *Adolescence, 37(146).* 373–393.

Bisiach, E., Perani, D., Vallar, G., Berti, A. (1986): Unilateral neglect: Personal and extrapersonal. *Neuropsychologia 24.* 759-767.

Bonnier, P. (1905): L'Aschématie [Aschematia]. *Revue Neurologique (Paris), 13.* 605–609. id. de Vignemont, 2010

Buxbaum, L. J., Coslett, H. B. (2001): Specialised structural descriptions for human body parts: Evidence from autotopagnosia. *Cognitive Neuropsychology, 18*. 289–306.

Csathó Á. (2008): A vizuális észlelés neuropszichológiája. In: Kállai J, Bende I, Karádi K, Racsmány M (szerk.) *Bevezetés a neuropszichológiába*. Medicina, Budapest.

Damasio, A.R. (1994/1996): *Descartes tévedése. Érzelem, értelem és az emberi agy*. AduPrint, Budapest.

Dijkerman, H.C., de Haan, E.H. (2007): Somatosensory processes subserving perception and action. *The Behavioral and Brain Sciences, 30*. 189-201.

Ferber S, Karnath H. (1999): Parietal and occipital lobe contributions to perception of straight ahead orientation. *Journal of Neurology Neurosurgery Psychiatry, 67.* 572-578.

Gallagher, S. (1986): Body image and body schema: A conceptual clarification. *Journal of Mind and Behavior, 7*. 541-554.

Gallagher, S. (2005): *How the body shapes the mind*. Oxford University Press, New York

Gallese, V., Sinigaglia, C. (2010): The bodily self as a power for action. *Neuropsychologia, 48(3).* 746-755.

Guariglia, C., Antonucci, G. (1992): Personal and extrapersonal space: a case of neglect dissociation. *Neuropsychologia, 30(11).* 1001-1009.

Head, H., Holmes, H.G. (1911): Sensory disturbances from cerebral lesions. *Brain, 34.* 102-254.

Heilman, K.M., Bowers, D., Watson, R.T., (1983): Performance on hemispatial pointing task by patients with neglect syndrome. *Neurology 33.* 661-664.

Heilman, K. M., Watson, R. T., Valenstein, E. (1993): Neglect and related disorders. In: K. Heilman, E. Valenstein (Eds.) *Clinical neuropsychology (3rd ed.).* 279–336).

Ivanenko, Y.P., Dominici, N., Daprati, E., Nico, D., Cappellini, G., Lacquaniti, F. (2011): Locomotor body scheme. *Human Movement Science, 30.* 341-351.

Karmiloff-Smith, A. (1994/1996): Túl a modularitáson: A kognitív tudomány fejlődéselméleti megközelítése. In: Pléh Csaba (szerk.) *Kognitív tudomány.* Budapest, Osiris, 254-281.

Keeton, P. W., Cash, F. T., & Brown, T. A. (1990): Body image or body images?: Comparative, multidimensional assessment among college students. *Journal of Personality Assessment, 54(1-2).* 213–230.

Kerkhoff, G. (2001): Spatial hemineglect in humans. *Progress in Neurobiology, 63.* 1-27.

Laplane, D., Degos, J.P. (1983): Motor neglect. *Journal of Neurology, Neurosurgery, and Psychiatry, 46*. 152-158.

Longo, M.R., Azanón, E., Haggard, P. (2010): More than skin deep: Body representation beyond primary somatosensory cortex. *Neuropsychologia, 48(3).* 655-668.

Marton M. (1970): Tanulás, vizuális-poszturális testmodell és a tudat kialakulása. *Magyar Pszihcológiai Szemle, 27*. 182–197.

Marton M. (1998): Útban az éntudat kialakulása felé II. A tudat testérzékleti eredete. *Pszichológia, 18,* 4. 379–435.

Marton M. (2005): Az idegrendszeri önreprezentáció kérdései. *Pszichológia, 25*. 3–26.

Meador, K. J., Allen, M. E., Adams, R. J., & Loring, D. W. (1991): Allochiria vs Allesthesia. Is there a misperception? *Archives of Neurology, 48(5)*. 546-549.

Medina, J., Coslett, H.B. (2010): From maps to form space: Touch and the body schema. *Neuropsychologia, 48(3).* 645-654.

Rogers, C. R. (1951/1980): Személyiség és viselkedés-elmélet. In: Szakács F., Kulcsár Zs. (eds.) *Személyiséglélektani szöveggyűjtemény. II.* Tankönyvkiadó, Budapest. 369–404.

Schwoebel, J., Coslett, H.B. (2005): Evidence for multiple, distinct representations of the human body. *Journal of Cognitive Neuroscience, 17*. 543-553.

Sirigu, A., Grafman, J., Bressler, K., & Sunderland, T. (1991): Multiple representations contribute to body knowledge processing. *Brain, 114*. 629–642.

Slaughter, V., Heron, M., Sim, S. (2002): Development of preferences for the human body shape in infancy. *Cognition, 85*. 871-881.

Squire, L.R. (2004): Memory systems of the brain: A brief history and current prespective. *Neurobiology of Learning and Memory, 82*. 171-177.

Szabó P. (2000): A testkép és zavara. In: Túry F., Szabó P. (szerk) *A táplálkozási magatartás zavarai: anorexia nervosa és a bulimia nervosa*. Medicina, Budapest. 59-75.

Treisman, A. (1996): The binding problem. *Current Opinion in Neurobiology, 6.* 171–178.

Treisman, A. (1998): Solutions to the binding problem: Review progress through controversy sumery and convergence. *Neuron, 24.* 105-110.

Verseghi A., S. Nagy Z. (2011): Felülről lefelé tekintve. Corticalis sérülés következtében megjelenő vizuális zavarok. In: Somlai J. (szerk.) *Neuroophthalmologia.* Nosza Alapítvány, Budapest, 384-393. ISBN:978-963-08-1357-0. letölthető: www.nosza.eu

de Vignemont, F. (2010): Body schema and body image – Pros and cons. *Neuropsychologia, 48(3).* 669-680.

V.Komlósi, A. (2007): Napjaink önértkelés-kutatásainak áttekintése: önértékelés és/vagy önelfogadás? In: Demetrovics, Zs., Kökönyei, Gy., Oláh, A. (szerk.) *Személyiséglélektantól az egyészségpszichológiáig. Tanulmányok Kulcsár Zsuzsanna tiszteletére.* Trefort Kiadó, Budapest. 20–46

Wernicke C (1906): *Grundrisse der Psychiatrie*. Leipzig, Germany: Thieme. id Szabó, 2000

White, R. W. (1959/1988): A motiváció fogalmának kritikai áttekintése: A kompetencia fogalma. In: Barkóczi I., Séra L. (eds.): *Az emberi motiváció II.* Tankönyvkiadó, Budapest. 51–103..

Wolpert, D.M., Kawato, M. (1998): Multiple paired forward and inverse models for motor control. *Neural Networks, 11*. 1317-1329.

Wolpert, D.M., Ghahramani, Z., Flanagan, J.R. (2001). Perspectives and problems in motor learning. *Trends in Cognitive Sciences, 5*. 487–494.

Wortis S.B., Bender, M.B., Teuber H-L. (1948): The significance of the phenomenon of extinction. *Jounal of Nervous and Mental Disease, 107.* 382-387.

PUBLICATIONS FROM THE AUTHOR IN THE TOPIC:

S. Nagy Z. (2006): *Jobb és bal oldali agysérültek vizsgálata neuropszichológiai eszközökkel. Éntudatosság agysérülés után*. Szakdolgozat. Budapest, ELTE PPK Pszichológiai Intézet Könyvtára

S. Nagy Z. (2008): Neglektes betegek funkcionális testképének vizsgálata. *Rehabilitáció, 18(4).* 177-183.

S. Nagy Z., Olasz K. (2010): Az önértékelés és a szenzomotoros testséma kapcsolatának értelmezése az éntudat kialakulásának fényében. *Alkalmazott Pszichológia, 3-4.* 69-86.

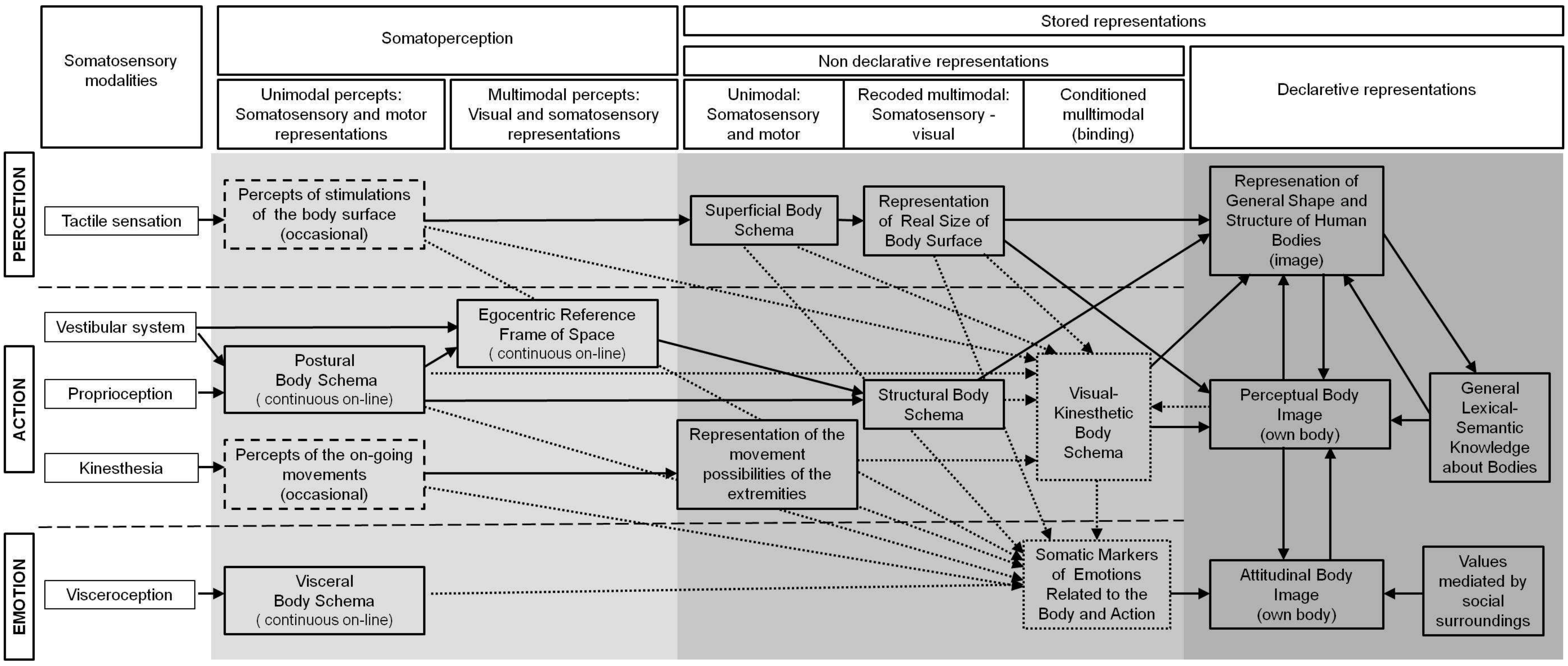
S.Nagy Z (2012): Testleképeződés és mozgás. Magyar Pszichológiai Társaság XXI. Országos Tudományos Nagygyűlése, 2012. május 30 - június 1. Szombathely. A tudomány emberi arca, *Kivonatkötet*, 371. o. (poszter absztrakt)

SNagy, Z., VKomlósi, A., Rákóczi, B., Verseghi, A. (2012): *Body schema and body image: a development oriented model of body representation and a comprehensive interpretation of personal neglect.* Kézirat.

SNagy Z, Verseghi A, VKomlósi A, Rákóczi B, Boros E. (in press): Multiple disruption of body representation in neglect. *Clinical Neuroscience (Ideggyógyászati Szemle).* Elfogadva: 2013. 01. 11

Verseghi A., S. Nagy Z. (2011b): Figyelmen kívül hagyott világ. A neglect. In: Somlai J. (szerk) *Neuroophthalmologia.* Nosza Alapítvány, Budapest. 394-401. ISBN:978-963-08-1357-0. letölthető: www.nosza.eu

APPENDIX: THE DIAGRAM OF THE FLOWMODEL OF BODY REPRESENTATION



Somatosensory inputs from different modalities provide the bases of our knowledge about the body. This is represented on the left border of the diagram. Information is processed in the cognitive system on different levels: after perception, information could be stored on a basic nondeclarative level, and subsequently some part of it could become a declarative knowledge. During the process of somatoperception, the representations are in fact percepts; some of which are continous whereas others are occasional percepts (previous are represented by solid lines, latter are drawn by broken lines).

One possible way of the development of body representation is, that implicit knowledge is recoded through the integration of other (especially visual) modalities, and then it becomes a multimodal non-declarative, and in the end a declarative representation (image or lexical-semantic knowledge). This developmental process is portrayed by solid arrow on the diagram. However, there is another way of the development, which involves the conjunction of the different stored information. This „binding" process (see Treisman, 1996, 1998) rather results in conditioned than recoded multimodal body representations. This process is represented by dotted arrows and dotted oblong. On a declarative level lexical-semantic knowledge will be added to the existing perceptual and motor experiences. Detailed description of the process of body representation and its' elements can be found in the text.