

# **Sensory Stimulation Process and Cognitive Function among Persons with Traumatic Brain Injury: A Case Study**

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**Abstract :** Severe traumatic brain injury alters cognitive function and impacts on self-reliance in the long-term but sensory stimulation may facilitate cognitive rehabilitation. This case study involved a convenience sample of two persons with severe traumatic brain injury admitted to two hospitals in Central Thailand who could possibly benefit from sensory stimulation in hospital and later at home. Their six family caregivers also participated in the study. Data were collected via in-depth interviews, observation, and a reflective journal and three cognitive assessment instruments. The latter were: The Glasgow Coma Scale, The Rancho Los Amigos Scale and The Sensory Modality Assessment and Rehabilitation Technique. Results revealed that the sensory stimulation processes proved efficient and were: readiness preparation for caregivers as providers of sensory stimulation in hospital and later the home environments; design and application of sensory stimulation; and monitoring for cognitive function as evidenced by sensory stimulation responses. Findings provide vital information to nurses, healthcare providers, and family members about: the success of sensory stimulation given by family providers, especially the parents; the intimate environment, particularly the home environment; the sensory stimulation design based upon the existing level of cognitive function; and maintaining the provider's motivation through their ability to notice the positive responses towards the stimulation. In addition, close monitoring of the responses throughout the sensory stimulation process proved more appropriate than using the existing cognitive function assessment scale. Results also revealed possible effects of sensory stimulation on cognitive function improvement with no observable negative consequences in the two cases studied. Further testing of this program is required with larger samples, and the results of these may help to develop future nursing practice guidelines in Thailand regarding caring for people with traumatic brain disorder.

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**Keywords:** Case study, Caregivers, Cognitive function, Rehabilitation, Sensory stimulation, Sensory stimulation process, Traumatic brain injury.

## **Introduction:**

Traumatic brain injury (TBI) is a leading cause of death, disability, and health and socioeconomic burdens worldwide.<sup>1</sup> For example, in 2010, approximately 2.5 million Americans sustained TBI, with almost half surviving with disability and an

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estimated medical cost of 76.5 billion dollars.<sup>2</sup> In 2012, approximately 23,600 Thais suffered from TBI.<sup>3</sup> However, this prevalence may be under-reported due to incomplete systemic data collection.

At present, there is an increasing number of survivors of severe TBI,<sup>4,5</sup> which causes neuron injury and disrupts cognitive processes.<sup>6</sup> In some cases, cognitive recovery may naturally occur 3–6 months after injury<sup>7</sup> through neuronal mechanism, namely brain reorganization, axon regeneration, sprouting, and plasticity.<sup>8,9,10</sup> People who are cognitively-impaired have altered self-reliance and ability to appropriately react to their environment. Therefore, enhancing cognitive rehabilitation is important.

Sensory stimulation (SS) is considered by some as a strategy to facilitate the recovery of cognitive function.<sup>11,12</sup> However, available evidence reveals that the inconsistent effects of SS range from no effect to some degree of improved cognitive function.<sup>13,14,15</sup> Therefore, the process of SS needs to be explored further through research. Each individual with TBI requires a different level of the cognitive progression after brain injury. Designing the sensory stimuli, the duration and frequency of the SS might be dissimilar. Intervention approaches have strict protocols to follow, but these do not provide exploration of the process of providing SS. The latter is designed to provide the appropriate sensory stimuli according the level of cognitive function that might change across time.

### **Literature Review:**

Cognition is the human ability to think, feel, and act.<sup>16</sup> It consists of attention, memory, learning, concept formation, abstraction, thinking or thoughts, judgment, reasoning, executive function, and insight.<sup>17</sup> Cognition is the process starting from SS transmitted to neurons in the form of nerve impulse to particular areas in the cerebral cortex.<sup>18</sup> The output of this process is a message in the form of nerve impulses from the brain to motor neurons which the person will be able

to express by their behavior.<sup>18</sup> Normally, cognition is processed through neurons that transmit the sensory stimuli received from the environment and transducerstonerve impulses. The nerve impulses are then sent to be processed at a specific area in the cerebral cortex; they then travel through motor neurons and generate responses, which are known as behavior.<sup>18</sup> Therefore, neuronal injury resulting from TBI results in the disruption of the above process resulting in impaired cognitive function.

SS is an intervention that promotes brain organization by stimulating the reticular activating system through the sensory information received from 6 senses: auditory, visual, olfactory, tactile, gustatory, and kinesthetic.<sup>9,12</sup> Compared to unimodal SS, multimodal SS is mostly used, and it is suggested that this is applied as soon as the person is clinically stable.<sup>12,19</sup>

While initiating SS, the nerve impulses generated from external and internal stimuli are sent to the cerebral cortex. These neuronal responses to these stimuli will reorganize or regenerate the injured axons through the activated uninjured axons; thus, collateral fibers are generated or branch out in all directions.<sup>9</sup> Recovery of the injured brain usually takes place at a rapid rate, and cortical and cognitive recovery regain at a faster rate.

A number of studies have investigated the effect of SS in persons with severe TBI. The timing and intensity of the SS varies, for instance, SS was initiated in persons with TBI ranging from an acute phase in the ICU to the rehabilitation phase in a rehabilitation setting.<sup>14,20,21</sup> The duration of SS can also vary: a short period (1–2 weeks)<sup>14,22,23</sup> to an intermediate period (1–3 months)<sup>24,25</sup> and a long period (1 year).<sup>21</sup> In terms of frequency SS can be provided ranging from one session to several per day.<sup>26,27,28</sup>

The benefits of SS have been demonstrated by: an increased the level of consciousness as assessed by the GCS<sup>23</sup>; decreased duration of coma<sup>29</sup>; increased level of cognitive function assessed by RLAS<sup>13</sup> and SMART<sup>14</sup>; improved functional status assessed by Glasgow Outcome Score (GOS), the Barthel Index,

the Functional Independence Measure (FIM), the Disability Rating Scale (DRS)<sup>28</sup>; and increased behavioral responses.<sup>23</sup>

Theoretically, an adverse effect of SS could be increased intracranial pressure (ICP). Auditory stimulation may cause an increase ICP through increasing global cerebral blood flow (CBF) and enhancing regional CBF to the auditory areas of the brain.<sup>30</sup> However, a literature review demonstrated that there was no evidence of adverse effect of sensory stimulation.<sup>13,14,29</sup>

Although SS is suggested to be applied appropriately to the level of cognitive function, previous studies provided SS based on a pre-designed program.<sup>13,14,26</sup> To enhance the speed and degree of recovery, the levels of cognitive function must be periodically investigated and stimuli should be carefully designed and given accordingly. Additionally, SS should be done continuously throughout the period of time from the acute to rehabilitation period. No studies have investigated effects of long-term application of SS from the acute through the rehabilitation phase. In addition, no studies have suggested the effect of SS application.

In terms of outcomes, most studies have measured cognitive functions as the outcome of SS provision.<sup>13,14,15</sup> The Glasgow Coma Scale (GCS), the Rancho Los Amigos Level of Cognitive Function Scale (RLAS), and the Sensory Modality Assessment and Rehabilitation Technique (SMART) have been commonly used to capture changed cognitive function. The GCS has been mostly used to assess cognitive function in the acute phase as well as SMART, which assesses cognitive function in the acute phase.<sup>14,25,25</sup> The RLAS was mostly used to explore cognitive function during the rehabilitation phase.<sup>21,30</sup> No studies could be found that have measured cognitive function alongside the process of SS from the acute to the rehabilitation period.

In view of the above, a case study approach<sup>31</sup> was used in this research to explore the SS process and changes to the cognitive function of the person

with TBI throughout the process. Information gained will help provide an in-depth understanding about the needs of the health care provider, or caregiver, towards SS. This will also assist in understanding the modification of a future SS program that will assist in enhancing the cognitive function and abilities of people with TBI.

**Aim:** To explore the SS process and cognitive function among the persons with TBI and the application of SS by caregivers.

## **Method:**

**Design:** A case study design was chosen because it had the potential to focus on exploring the process of SS within a real-life context.<sup>31</sup> Moreover, a case study design enables both qualitative and quantitative data to be collected and analyzed, giving a more holistic picture of the case under study.

**Setting and participants:** The participants were two persons with severe TBI and six of their caregivers. They were recruited by purposive sampling from two tertiary hospitals located in Central Thailand, as well as the homes of the participants. Inclusion criteria of the two participants were: diagnosed by a physician with severe TBI (GCS 3–8) on admission; age ≥18 years; had physicians' permission to participate in this study; and had written consent from their legal surrogate. Caregiver inclusion criteria were: being an anticipated home caregiver; having a commitment to being an SS provider; and willing to participate in the study.

**Ethical considerations:** Approval was obtained from the Research Ethics Review Committee, Faculty of Nursing, Chiang Mai University, and the research ethics committees of the two hospitals. Written consent form was obtained from the participants' legal surrogates and the caregivers after the details of the study, rights and benefits were clearly explained. The privacy and confidentiality of their information were ensured, and their participation was entirely voluntary. An

identification number was assigned to each participant, and audio-recorded information was coded with numbers.

**Data collection:** Data were gathered over a 6-month period through three major phases: recruitment, preparation, and application of the designed SS. In addition to quantitative data gathering described above, qualitative data were also collected through interviews, reflective notes of the researcher and observations of the participants.

### **Instruments**

The cognitive functions among the person with TBI were assessed through three instruments, and close observation by the principal investigator (PI) was done to capture change in cognitive function that may not be able to measure by those standard measurements.

*The Glasgow Coma Scale* (GCS) developed by Teasdale and Jennett in 1974,<sup>32</sup> has three different aspects of response, eye opening, verbal response and motor response. It was used to assess level of consciousness that reflected cognitive ability among the persons with TBI. The score of responses ranged from 3–15, of which 3 indicates the lowest level of consciousness while 15 indicates the highest level. The inter-rater reliability previously was 0.864.<sup>33</sup> The reliability in this study was 1.

*The Rancho Los Amigos Scale* (RLAS) was developed by Hagen et al. in 1972 and translated into Thai by Chaiwang and Sukonthasarn in 2006<sup>13</sup> and is a 10-level scale. It is used to assess the individuals' behavioral responses to stimuli reflecting the person's cognitive ability. Scores of responses range from 1–10, with 1 indicating no response and 10 purposeful and appropriate response of cognitive function. The inter-rater reliability of the RLAS was 1.<sup>13</sup> In this study, the inter-rater reliability of RLAS was 1. Baseline RLAS assessment was done by the PI and then weekly RLAS assessment after SS implementation were completed by both the PI and trained caregivers.

*The Sensory Modality Assessment and Rehabilitation Technique* (SMART) developed by Gill–Thwaites and Munday in 1999,<sup>34</sup> assesses 5 modalities of senses for visual, tactile, auditory, olfactory, and gustatory stimuli, a patient's level of wakefulness, functional motor, and communicative ability. Urbenjapol<sup>14</sup> translated the 5 modalities into Thailand applied the tool in her study to assess the state of awareness demonstrated by distinct cognitive capacities. In the present study, weekly assessment after SS implementation was done by the PI and trained caregivers. Scores of response range from 5–25, with the lower scores indicating a low level of cognitive capacity and higher scores indicating a high level of cognitive capacity. The SMART has a previous inter-rater reliability of 0.94.<sup>14</sup> In this study, the inter-rater reliability of RLAS was 1.

#### **Preparation**

Three steps of preparation ensured the readiness of the participants:

1) The stable condition of the persons with TBI was confirmed by stable vital signs indicated by body temperature (T) 36.5 to 37.5°C; pulse rate (P) 60–100 times/min; respiratory rate 12–20 times/min; blood pressure 90–130/60–90 mmHg; and oxygen saturation  $\geq 95\%$ .

2) The commitment of the primary caregivers to provide SS was revealed by verbal confirmation. Training in SS and discussions and observations on their SS work were done by the PI to ensure that they gained enough knowledge, had positive attitudes and relevant skills for providing the SS.

3) Observations and work in the environment included collaborating with nursing staff for example about daily hygiene needs and the patient's bed. This also required work by the PI to raise nursing personnel's awareness, knowledge and skill levels in providing care for the persons with TBI, thus SS training was given.

#### **Application of the designed SS**

This phase aimed at re-education, reorganization, or regeneration of the injured brain. Designing for proper SS, the pathophysiology of the injured brain

and RLAS were carefully assessed to identify the remained senses. In order to avoid possible sensory overload among the persons with TBI, SS was first provided by integrating it into the routine nursing care while closed monitoring for physiological responses through vital signs and oxygenation status were done simultaneously.

Throughout the SS process, daily closed observation and weekly GCS, RLAS, and SMART were used to capture the changing results from the SS. In addition, observations were noted for the responses that those instruments could not capture. Along with these activities, three semi-structured in-depth interviews using a guide were conducted with the SS providers to assess their ability to design and provide the SS for the persons with TBI. Examples of interview questions were “How would you organize the SS procedures?”, “What do you see as the benefit of SS?”, “Have you arranged the SS in home environment for your relative and if so, what are the arrangements?” and “What kind of activity of SS would you provide?” The interviews lasted ~45–60 minutes each, were audio-taped, transcribed verbatim, and checked by the research team for accuracy.

### **Data analysis:**

Quantitative data in terms of cognitive function based on the GCS, RLAS, and SMART was compared across time to capture the progression of cognitive function. Qualitative data from in-depth interviews, observations, and reflexive journal was analyzed using the content analysis method described by Elo and Kyngäs (2007).<sup>35</sup> The PI first transcribed the qualitative data from audio-recordings, reviewed the data, coded it into preliminary categories, and then formulated and described the categories arising. The progression of responses along the process of SS was compared and contrasted to ascertain the possible improvement of cognitive function.

**Trustworthiness:** Prolonged engagement (57 days for Case 1 and 127 days for Case 2) and multiple sources of evidence<sup>31</sup> (methodological triangulation) including the weekly assessed cognitive function by instrument, in-depth interviews, participant observation of caregiver SS provision and persons with TBI’s response to the SS provision were used to ensure the rigor of this study. This engagement enhanced the researchers’ confidence regarding the provision of SS by caregivers, as well as confidence that the findings were valid. The triangulation technique was adopted to assure the reliability of the outcomes.

### **Results:**

#### **CASE 1: JJ**

JJ is a 27-year-old female who sustained severe TBI caused by a motorcycle accident. Initially, computed tomography (CT scan) showed acute subdural hematoma (SDH) in left the fronto-temporal area and epidural hematoma (EDH) in the left temporal area. Craniectomy to remove the blood clot was done within 3 hours post-injury and findings revealed the lesion in left hemisphere included the frontal, parietal and temporal areas. During hospitalization, oxygenation and perfusion were maintained via endotracheal tube and tracheostomy tube, respectively. Enteral feeding was managed by naso-gastric tube and medicines included antibiotics, Dilantin and Balcofen. These important latter treatments were also provided for JJ at home after discharge.

When the PI first met JJ in ICU, and read her medical history and clinical status, it was found she was being treated for respiratory tract infection and undergoing the process of respirator weaning. Her vital signs were quite stable. The pathophysiology of acute SDH in the left fronto-temporal area and EDH at left temporal area affected JJ’s process of cognitive function, including language expression and speaking, loss of voluntary control of the corresponding body part, alteration of received modality of sensory information and the ability to delineate sensations



(pain, touch, vibration, and pressure).<sup>36</sup> Through further investigation, the PI found that all JJ's sensory pathways were intact, thus multimodal SS including auditory, visual, tactile, gustatory, olfactory, and kinesthetic stimuli could be provided for JJ, and she seemed a good candidate for SS and this study.

### **Sensory Stimulation Process**

Four phases emerged in the SS process for JJ:

#### **1. Recruitment into study**

After JJ's was recruited into the study, three caregivers her mother, aged 50 and primary caregiver, and two aunts were also recruited. Her mother was the most familiar person to JJ and lived together in the same home with her son, daughter in law, and her grandchild. The two aunts, Som, 44 years, and Wan, 42 years, lived in JJ's home to help in providing care for JJ. During hospitalization, JJ's mother spent 3–4 hours during the week and 7–8 hours of a weekend to visit and care for JJ, while the two aunts provided care for 7–8 hours daily. Later at home, most of the routine care and SS were provided by the aunts (20 hours daily) while JJ's mother spent 6–8 hours daily. JJ's caregivers reflected their commitment to SS:

*SS is good option to help my daughter recover from coma. I will do all my best for her. Just tell me what I can do for her. (Mother)*

*I would like to help JJ to get back into her daily life, although it may not be the same. If only she can speak and be able to take care of herself and not be that much burden on others. (Som, 44 years)*

#### **2. Readiness preparation for SS providers and the environment:**

During the first two weeks of treatment for JJ, caregivers were trained to participate in SS so that it was integrated into routine nursing care. Caregiver readiness to provide SS is reflected below:

*SS is not difficult. I think that the more I practice, the more I have the skills of SS. (Som)*

*During giving care for JJ, I can apply the SS for her. I will able to do it as handed on learning more every day. (Wan)*

In hospital, the nurses prepared the caregiving environment using JJ's personal belongings and equipment provided by her caregivers. The home environment of JJ was same as before the injury except for JJ's bed, which was located outside bedroom for more convenient caregiving.

#### **3. Design and application of sensory stimulation:**

Based on RLAS level 2 and pathophysiology of brain lesions, multimodal SS was integrated with JJ's care was designed and provided routinely (Table 1). A variety of sensory stimuli were selected and applied for JJ according to her responses to stimuli, with a gradual increase in such stimuli. For example, familiar photography or objects were presented soon after she opened her eyes. Fever that occurred did not limit the continuation of SS provision since this was integrated in routine nursing care (mouth care, bed bathing, changing position, and a range of motion exercise). Monitoring of vital signs and O<sub>2</sub> saturation during SS provision throughout these procedures showed normal levels. However, SS for JJ was discontinued on days 13 and 14 post-admission due to the development of ventilator-associated pneumonia.

**4. Monitoring for cognitive function as evidenced by sensory stimulation response:** Abnormal flexion of arms and spasticity were noticed during the first week of SS application without physiological changes, and later purposive responding to tactile and auditory stimuli were observed. For example, JJ responded to her mother's voice and gentle touches to her face and arm as there was a decreasing duration and degree of muscle spasticity. When her mother held JJ in her arms and informed that she was safe, JJ reacted by opening her eyes, looking at her mother's face, she had gradual decrease of her spasticity, and moved her lips. These were directly in response to the activities provided by her mother but were not observed by others. However these positive responses were also observed during SS provision at home and reflected the positive progression of JJ's cognitive recovery.

**Table 1.** SS-integrated care used in this study.

Nursing Activities	Senses					
	Auditory	Olfactory	Gustatory	Visual	Tactile	Kinesthetic
<b>Bed bath</b>						
- Applying water with a towel	✓			✓	✓	
- Rubbing skin with soap	✓	✓		✓	✓	
- Drying skin with towel	✓			✓	✓	
- Back rub	✓				✓	
- Positioning during bed bath	✓				✓	✓
- Applying body lotion	✓	✓			✓	
- Applying powder on skin	✓	✓			✓	
<b>Mouth care</b>						
- Applying cold or warm water	✓		✓	✓	✓	
- Brushing teeth	✓	✓	✓	✓		
- Applying lipstick	✓	✓	✓	✓	✓	
<b>Hair washing</b>						
- Applying cold or warm water	✓			✓	✓	
- Applying shampoo	✓	✓		✓	✓	
- Massaging head with fingers	✓			✓	✓	
- Drying hair with towel	✓				✓	

The PI encouraged caregiver motivation to provide SS provision, for example:

*When JJ smells her favorite beverage, her lips move like she sucks on something. These responses motivate me to continue providing SS to enhance her recovery. I want to help her drink her favorite beverage as soon as possible. (Som, 44 years)*

*When I told JJ “move your arm and extend your elbow”, I noticed that she tried to move her arm to be extended. I don’t know whether she can remember or not but I will keep on doing all the best for her, although her best possible recovery will be very small. (Mother)*

At home JJ’s mother noticed that she increased her responses to stimuli but had limited attention. For example, when a favorite television show was turned on, JJ directed her eyes to this for a few seconds and later turned her eyes away. Thus, her mother planned

to try to increase stimulation:

*If I provide SS more often for her, her recovery will be faster. I think SS should not be provided once a day but should be many times a day.*

*If JJ still cannot do some activities according to the command, she needs more practice.*

**Cognitive function:**

Baseline cognitive function of JJ and its improvement are shown in Table 2.

**CASE 2: BB**

BB is a 19-year-old male who sustained severe TBI (GCS 3) in a motorcycle accident. A CT scan showed brain stem hemorrhage and intraventricular hemorrhage. Brain stem injury was displayed in lesions at the medulla, pons, and midbrain. Damage to these areas was possibly caused by an impaired cranial nerve (CNS) III to XII which involved weakness in all extremities and difficulties in swallowing and speaking. In addition, it may damage the reticular formation (RF)

resulting in impaired the regulation of blood pressure and respiration.<sup>36</sup> Throughout 106 days of admission, conservative treatment including oxygenation, fluid resuscitation, medicines, (antibiotics, anti-inflammatory, anticonvulsant), and enteral feeding via naso-gastric tube were administered. Additionally, tracheostomy was performed after 14 days of intubation. A follow-up CT scan on day 10 after injury showed a resolved brain stem injury. The PI first approached BB in ICU, and the medical history and clinical status assessment revealed stable vital signs and adequate oxygenation. Despite the above, neurological assessment demonstrated his sensory pathway still intact and he fitted the inclusion criteria for the study.

### ***Sensory Stimulation Process***

Four phases again emerged in the SS process:

#### ***1. Recruitment into study:***

BB was recruited as well as his mother, father, and aunt as caregiver participants. His mother, who was closest to BB, was 48 years old, and diagnosed with CA lung, and his father was aged 55 years. Throughout hospitalization, the caregivers spent varying amounts of time in providing care for him. During the working week, BB's mother, Prai, provided care for 3 hours while his father and aunt cared for 1-2 hours. During weekends, Prai spent 7-8 in visiting and caring while the father visited for 2 hours. Prai was first approached in ICU and she was concerned about his clinical progression and hoped for his recovery, but she reflected her willingness to care and commitment to SS:

For SS, I think I can do for him whenever I have time. I just cannot leave out providing SS for him since I want him to recover as soon as possible. I do hope that SS will help my son at least return to his daily life although he has some neurological impairment.

#### ***2. Readiness preparation for SS providers and the environment.***

Similar training and activities occurred for SS as mentioned above for JJ, resulting in the following comments from caregivers:

*Sensory stimulation is not difficult but it needs time to be provided continuously. (Prai)*

For sensory stimulation, I am trying to do my best sensory stimulation for my son although I don't know how much and how long that I have to do for him. The more I practice, the more I gain the skill and I can continue to use at home.(Noi)

In the hospital, the nurses undertook similar roles caring for BB as for JJ. The home environment of BB was same as before injury except that BB's was located outside bedroom for more convenient care. Similar to JJ, BB's mother provided his personal belongings to use within the hospital environment and continued their use at home.

#### ***3. Design and application of sensory stimulation.***

Multimodal SS integrated was integrated into BB's (Table 1) according to the RLAS level 2 and the pathology of his brain stem injury. The application of SS in this case was quite similar to that for JJ. SS was discontinued for a couple of days at weeks 7 and 12 due to the development of VAP, sepsis, and urinary tract infection.

#### ***4. Monitoring for cognitive function as evidenced by sensory stimulation responses.***

At the beginning, BB started to respond to tactile stimuli with the extension of his extremities and he responded to gustatory stimuli with lip movements. Again, the responses were seen mostly when SS was provided by his mother. The PI observed that BB responded to his mother by moving his lips when she gently patted his head and face as well as spoke to him. Later, BB had tears in his eyes when his mother talked to him about his condition and burden of care. In addition, BB responded during range of motion exercise provided by his father by decreasing his spasticity. It was noted that the magnitude of positive responses depended upon the SS providers. His mother seemed to be the most significant person for him as he responded to her the most, whereas he responded to his aunt's SS provision the least. Similar to that of JJ, BB's positive response detection motivated his SS providers, as his parents stated:

*I have good news for you. BB can lift his head up from the bed and move his left arm over his shoulder. I am very happy to see that.(Prai)*



*At home, even I see the little improvement of my son. I will continue to provide the sensory stimulation and hope for the best possible recovery. (Noi)*

**Cognitive function**

Baseline cognitive function of BB and its improvement are also shown in Table 2.

**Table 2.** Cognitive function of JJ and BB

	JJ			BB		
	Baseline	Discharge	Termination	Baseline	Discharge	Termination
GCS	5	9	9	4	8	8
RLAS	2	2	3	2	3	3
SMART	7	14	18	8	18	16

**Discussion:**

The focus of this discussion will be on the process of SS and the response towards sensory stimulation that reflected the improvement of cognitive function in both case studies. Findings demonstrated that JJ (Case 1) who suffered from fronto-parieto-temporal hematoma had faster improvement of cognitive function than BB (Case 2), who suffered from brain stem injury. Marshall and his colleagues<sup>36</sup> explained that the anatomy of the brain stem involves both sensory and motor pathways. Each component of the brain stem has pathways of afferent fibers that carry information after processing it to the motor pathway in order to be exhibited as motor responses. Damage to this pathway, results in malfunction of the afferent fiber and caused weakness of all extremities. Particularly, fronto-parieto-temporal hematoma that involves the cerebral cortex and frontal lobe may impair attention span, which is a fundamental process of cognition.<sup>17</sup>

Results demonstrated that both participants began responding to SS in a reflexive way and progressed towards more purposive responses. The reflexive responses reflected the sensory stimuli mediating to subcortical function.<sup>36</sup> This implies that impulses of sensory stimuli were sent to the brain but there was no meaning to the process and correspond to as cognitive function among the persons with severe TBI. In addition, the brain lesions limited the pathways for signaling the sensory

information; thus, the sensory information could not be sent properly to the cortical area so as to process higher cognitive functions. The details of the changed responses were assessed by careful observation day-by-day. The standardized scales, particularly the RLAS, however, could not capture the small cognitive function changes but observable responses. Correspondingly Auantri<sup>22</sup> used behavioral response observation before and after presenting auditory stimuli. Another study<sup>21</sup> used two video cameras to record the behavioral responses after presenting auditory stimuli and the findings revealed significantly different responses before and after SS in the intervention group.

Our study results also indicate that the mothers were the most significant person to the participants, and considered the most suitable to provide SS since they had more positive responses compared to other caregivers. An explanation for this could be that people with TBI recognize the sensory stimuli provided by their mothers, the primary caregiver of their lives. During infancy, babies develop secure attachments with their mothers' care-giving through tactile, visual, olfactory, auditory, and gustatory senses.<sup>37</sup> Thus, the people with TBI are able to recognize the sensory stimuli from their mother, especially the mother's voice, from their early lives.<sup>38</sup> Mothers' voices enhance the secure attachment pattern through a warm, intimate, and continuous relationship.<sup>39</sup>

The findings also show that complications such as VAP, UTI, and sepsis interrupted the continuation of SS provision and the progression of cognitive recovery. Physiological changes (i.e., fever, tachycardia, decreased blood pressure) occurred during these complications and the participants could not safely receive the provided SS. Urbenjaphol<sup>14</sup> found that infection was one barrier to providing continuous SS.

Gradual improvements of cognitive function during and after the SS provision for the two participants were demonstrated, but the standardized scales used in this study were not sensitive enough to capture small changes in cognitive responses. Correspondingly, in other studies there was a significant difference when using behavioral response observation<sup>23</sup> and significant increased changes in the behavioral responses of intervention group.<sup>17</sup>

#### **Lessons learnt from this case study**

The pathophysiology of individuals should be taken into consideration before designing a suitable SS, which can be safely begun when the patient is clinically stable. Care can be integrated with routine daily nursing care with careful assessment for the readiness of the person for SS and close monitoring to prevent sensory overload. Close and careful observation of an individual's responses is necessary to the design of SS. Continuation of meaningful SS can be made possible through participation by family caregivers, who often have strong motivation and commitment.

#### **Limitations and Recommendations**

When applying the findings, the study's limitations need to be taken into consideration. Only two people with TBI and their caregivers, from two hospitals, were part of the study. Thus, generalizability of the findings is very limited. Future studies, including longitudinal studies, need to consider to include larger samples of participants with TBI admitted in a variety of sites throughout Thailand.

#### **Conclusions:**

This study explored the SS process and cognitive function among two people with TBI. Findings highlight the SS process to include 1) recruiting people with severe TBI who could possibly benefit from SS and their primary caregivers; 2) readiness preparation for the anticipated SS providers and environment; 3) design and application of the SS; and 4) monitoring for cognitive function as evidenced by SS responses.

Findings demonstrated that there were improvements to cognitive function as evidenced by observed responses and cognitive function assessment tools. The observation during and after SS provision provided more details regarding the responses to SS. Besides using the three instruments (GCS, RLAS, and SMART) to assess the level of cognitive function, close observation for reflexive and purposive responses of cognitive function has great potential to provide additional information to design appropriate SS for people with TBI.

#### **Implications for Nursing Practice:**

Based on the findings, some implications for nursing administration and nursing practice are as follows: In the clinical setting, nurses can create an intimate environment for the persons with TBI so as to promote re-education and re-organization of the injured brain. Providing the opportunities for family members, especially mothers, to be involved in the process of SS provision helps to enhance cognitive recovery among the persons with TBI. In addition, nurse administrators can facilitate the development and implementation of SS clinical practice guidelines for persons with TBI.

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## กระบวนการการกระตุ้นประสาทสัมผัสและความสามารถในการรับรู้ในผู้ที่มีภาวะบาดเจ็บสมอง

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**บทคัดย่อ:** การบาดเจ็บที่สมองระดับรุนแรงส่งผลให้เกิดการเปลี่ยนแปลงการรับรู้รวมถึงกระทบต่อความสามารถในการพึ่งพาตนเองของบุคคลในระยะยาว การกระตุ้นประสาทสัมผัสอาจช่วยส่งเสริมการฟื้นฟูสภาพการรับรู้ กรณีศึกษานี้ศึกษาในผู้ที่มีภาวะบาดเจ็บสมองรุนแรงจำนวน 2 รายรับไว้ในโรงพยาบาลภาคกลาง ประเทศไทย ที่อาจจะได้รับประโยชน์จากการกระตุ้นประสาทสัมผัสในโรงพยาบาลและที่บ้าน และผู้ดูแลจำนวน 6 รายเก็บรวบรวมข้อมูลโดยการสัมภาษณ์เชิงลึก การสังเกต บันทึกการสะท้อนคิด และแบบประเมินการรับรู้จำนวน 3 ฉบับได้แก่กลาสโกว์ โคม่า สเกล ระดับการรับรู้เรโนโซลอสอะมิโกส และแบบบันทึกการประเมินการฟื้นฟูสภาพ

ผลการศึกษานี้พบว่ากระบวนการการกระตุ้นประสาทสัมผัสในผู้ที่มีภาวะบาดเจ็บสมองประกอบด้วย 1) การเลือกผู้ที่มีภาวะบาดเจ็บสมองที่น่าจะได้รับประโยชน์และผู้ดูแล 2) การเตรียมความพร้อมผู้ที่จะให้การกระตุ้นประสาทสัมผัสหลักและสิ่งแวดล้อม 3) การออกแบบและการกระตุ้นประสาทสัมผัส และ 4) การติดตามประเมินความสามารถในการรับรู้จากการตอบสนองต่อการกระตุ้นประสาทสัมผัส

ผลการศึกษานี้ให้ข้อมูลสำคัญสำหรับพยาบาล บุคลากรด้านสุขภาพและสมาชิกครอบครัว ว่าความสำเร็จของการกระตุ้นประสาทสัมผัสขึ้นอยู่กับ 1) สมาชิกครอบครัวที่ให้การกระตุ้นประสาทสัมผัส โดยเฉพาะอย่างยิ่งมารดา และบิดา 2) สิ่งแวดล้อมที่ใกล้เคียงกับชีวิตประจำวันโดยเฉพาะอย่างยิ่งสิ่งแวดล้อม ที่บ้าน 3) การออกแบบการกระตุ้นประสาทสัมผัสที่มีพื้นฐานจากระดับความสามารถในการรับรู้ในขณะนั้น และ 4) การรักษากำลังใจของผู้ให้การกระตุ้นประสาทสัมผัสจากความสามารถในการสังเกตได้ถึงการตอบสนองต่อการกระตุ้นในทางที่ดี นอกจากนี้การประเมินความสามารถในการรับรู้โดยการติดตามการตอบสนองอย่างใกล้ชิดระหว่างกระบวนการการกระตุ้นประสาทสัมผัสมีความเหมาะสมมากกว่าการใช้แบบวัดความสามารถในการรับรู้ที่มีอยู่

ผลการศึกษายังแสดงให้เห็นถึงความเป็นไปได้ของผลการกระตุ้นประสาทสัมผัสว่าจะทำให้ความสามารถในการรับรู้ในผู้ที่มีภาวะบาดเจ็บสมองดีขึ้นโดยไม่พบผลด้านลบในกรณีศึกษาทั้ง 2 ราย ในการศึกษาครั้งต่อไปควรมีการทดสอบกระบวนการการกระตุ้นประสาทสัมผัสในจำนวนตัวอย่างที่มากขึ้นและผลของการศึกษานี้อาจช่วยพัฒนาแนวปฏิบัติการกระตุ้นประสาทสัมผัสในผู้ที่มีความผิดปกติจากภาวะบาดเจ็บสมองก่อนในประเทศไทย

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