行政院國家科學委員會專題研究計畫　成果報告

記憶系統中之自動與控制過程 -- 以電腦化的神經心理檢查與事件相關電位為研究方法

計畫類別：個別型計畫
計畫編號：NSC91-2314-B-002-212-
執行期間：91年08月01日至92年11月30日
執行單位：國立臺灣大學醫學院神經科

計畫主持人：邱銘章

報告類型：精簡報告
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中　華　民　國 93 年 3 月 5 日

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中文摘要

傳統上將認知功能時的覺知程度二分成自動化或控制性模式。熟悉的常規性工作，交給自動化模式去處理。複雜的工作則會啟動控制性模式，比如在處理上超出日常常規性工作之複雜度者，其次舊資料需用新方式加以處理時，或者必須加以創新處理的新資訊。

控制性模式的量測，以處理”隨機非結構”表徵之資訊時的反應加以量測。自動化模式的量測則針對俱”結構性序列”表徵之訊息的處理反應加以量測。事件相關電位則以 32 頻道之 NeuroScan 腦波機予以記錄。自動與控制則以 240 毫秒正波時之平均值以雙楔內插法運算得之，並計算其組間 T 值腦電波圖譜。刺激用之幾何圖形呈現在 15 吋之液晶銀幕上並以 60 公分之距離來觀看。每圖呈現一秒並有 300 毫秒之空白間格。對於第一組(8 個圖形)呈現之圖形，受試者須全神貫注並加以牢記。接著受試者須在第一及第二組(另 8 個圖形)隨機交錯出現之圖形進行辨認及”是”、”否”出現過之回答。第三階段辨認測試時又加入 16 個從未出現過之圖形，此時並同時記錄事件相關電位腦波，每組圖形會有總共 64 腦波之記錄。

實驗結果顯示，處理俱”結構性序列”表徵之訊息的反應時間(平均時長: 17.1 ± 3.1 秒)較處理”隨機非結構”表徵之資訊時的反應時間(平均時長: 15.5 ± 3.5 秒)為長。兩者之相差顯著(P=0.0002)。反應正確率也以處理”隨機非結構”表徵之資訊時為高(”隨機非結構” ：6.6 ± 4.3; ”結構性序列” ： 7.4±3.8)，兩者相差亦顯著(P=0.00569)。

事件相關電位腦波圖譜的研究，支持較熟悉之自動化制性模式其大腦部位在較後區，而不熟悉之新訊息的控制性模式則需動員大腦前區之資源加以應對處理。總之，本研究計畫運用電腦化的神經心理檢查與事件相關電位的研究方法探討了記憶系統中之自動與控制的過程並見證了其表現與其在大腦內的活性變化。

關鍵字 ： 自動與控制；腦電波圖譜；事件相關電位

英文摘要

The conventional concept about the level of awareness during cognitive processing can be divided in a dichotomy way into automatic and controlled processes. Routine tasks that we are rather familiar with go through automatic process. Complex tasks invoke controlled process when the level of complexity of a task requires more than routine processing, when old information must be considered in new ways or when the information is to be processed de novo. The measurement of the controlled process of the memory system was performed by using tasks with “random-disorganized” features, which invoked more awareness in handling the more complex situation. The measurement of the automatic process of the memory system was performed by using tasks with “structured-organized” features, which utilized less awareness in handling the less complex situation. ERP were recorded with a 32- channel ERP machine. Brain mappings were prepared at the mean latencies of P240 with the grand average of ERP using double spline interpolation. Between-group t-Maps were also constructed. Geometry shapes were presented to the subjects in a 15-inches LCD screen at about 60-cm distance. The shapes of the first group were presented for one second with an inter-break of about 300 ms. Subjects were instructed to pay full attention and to memorize them by heart. After the presentation the subjects were asked to recognize and to do a yes-no response on the shapes of the first group from a randomized presentation of shapes from the first (8 forms) and the 2^{nd} group (8 forms). ERP were recorded during the 3^{rd} stage of presentation and recognition test. Another 16 novel shapes that have never been presented joined in a random presentation sequence with the 1^{st} and 2^{nd} groups. In total 64 trials ERP were collected from each group for further analysis. It took longer to complete the “structured-organized” task (mean duration: 17.1 ± 3.1 sec） than to complete the “randomized-disorganized” task (mean duration: 15.5 ± 3.5 sec) with a statistic significant difference (p = 0.00002). The mean scores (correct – omission – commission) were lower (p = 0.00569) with “structured-organized” task (6.6 ± 4.3) than with “randomized-disorganized” task (7.4±3.8). In ERP study, the three conditions had similar waveforms especially the early components while their brain topographic mappings varied in the spatial distribution. The well-memorized targets induced activities over the bilateral parietal cortexes more on the right side. Those implicitly learned targets or de novo targets induced some frontal activities appeared in addition to parietal activities. In conclusion, “controlled process” recruits more brain resources but performs better in terms of speed and correct rates. ERP showed results compatible with that brain regions involved in this kind of automatic process are more posterior in location while the controlled process involves brain areas mostly within the frontal lobe.

Keywords : Automatic and control process; Brain mappings; Event related potentials

Introduction

The conventional concept about the level of awareness during cognitive processing can be divided in a dichotomy way into automatic and controlled processes. Routine tasks that we are rather familiar with go through automatic process. Brain regions involved in this kind of automatic process are more posterior in location. Complex tasks invoke controlled process when the level of complexity of a task requires more than routine processing, when old information must be considered in new ways or when the information is to be processed de novo. The controlled process involves brain areas mostly within the frontal lobe (Moscovitch & Winocur, 1995). In terms of memory function, the explicit memory tasks, such as recollection or recognition, have long been conceptualized to measure the conscious, controlled process of the learned material. By the same token, implicit memory tasks have also been conceived of measuring the automatic, unconscious process of the learning material because the patients are not required to refer consciously to the past experience to perform the tests (Besche-Richard et al., 1999; Moscovitch & Winocur, 1995). Actually, most recent researchers have already begun to realize that most of the memory tasks are not pure and that the performance on a particular task generally reflects the impact of more than on memory process or one memory system (Kazes et al., 1999; Danion et al., 1992). In other words, normal performance on either implicit or explicit memory tasks demands distinct levels of awareness (Besche-Richard et al., 1999).
The purpose of this study is to investigate cognitive process during different automatic or control levels using computer-controlled stimulation and response as well as to explore the event related potentials (ERP) during recognition of stimuli with different level of the automatic versus control process.

Methods and Subjects

Part I.

Measures of Controlled and Automatic Processes

Controlled-Strategic Processes

The measurement of the controlled process of the memory system was performed by using tasks with random-disorganized features, which invoked more awareness in handling the more complex situation.

Tasks with Random-Disorganized Features

We used shapes for the targets in the tasks with random-disorganized features.

Random-Disorganized Shape Subtest -1

- Stimulus items: 9 different shapes with a total of 270 stimuli (90 for each block)
- Target stimuli: one shape in each block; Target distribution: random-disorganized
- Subtest: 3 blocks; Block 1: 12/90; Block 2: 8/90; Block 3: 10/90
- Exposure time: 500-1000 msc
- Scoring Modes: Correct: /30; Omission; Commission

Automatic Processes

The measurement of the automatic process of the memory system was performed by using tasks with structured-organized features, which utilized less awareness in handling the less complex situation.

Tasks with Structured-organized Features

We also use shape for the targets in the structured-organized features.

Structured-Organized Shape Subtest-2

- Stimulus items: 9 different shapes with a total of 270 stimuli (90 for each block)
- Target stimuli: one shape in each block; Target distribution: random-disorganized
- Subtest: 3 blocks; Block 1: 12/90; Block 2: 8/90; Block 3: 10/90
- Exposure time: 500-1000 msc
- Scoring Modes: Correct: /30; Omission; Commission:
- Exposure time: 500-1000 msc
- Scoring Modes: Correct: /30; Omission; Commission:

Part II.

ERP during the "Controlled and Automatic Processes"

ERP were recorded with a 32- channel montage in a NeuroScan System (NuAmps, Compumedics, El Paso, Texas, USA), with a sampling rate of 1 KHz and a band-pass of 0.15-100 Hz. Evoked potentials were obtained from averages of 64 study blocks. Two additional eye channels were used to detect ocular movements. Blocks contaminated by blinks or eye movement artifacts (> ± 75 μV) were removed from further analysis. Baseline adjustments were to the mean amplitude of the whole segment. Visual recognition of waveforms at Cz was performed on -50 to 500 ms epochs. Peak was identified as the most positive peak between 150-400 ms and amplitude measured as peak-to-trough. Brain mappings were prepared at the mean latencies of P240 with the grand average of ERP using double spline interpolation. Between-group t-Maps were also constructed. Positions and t-values were reported with the nomenclature of the 10-10 international system.

Eight geometry shapes (1^{st} group) such formed that directly remember or recall with verbal cues were difficult were presented to the subjects on a 15-inch LCD screen at a distance of about 60 cm. The shape of the first group was presented with equal chance in a randomized sequence. The display was one second followed by a break of about 300 ms (a blank screen). Subjects were instructed to pay full attention and to memorize them by heart. The presentation lasted for more than 5 minutes. Subjects were asked to recognize the shapes of the first group from a randomized presentation of shapes from the first (8 forms) and the 2^{nd} group (another 8 forms) with a yes-no response during the presentation. Each shape of the first and 2^{nd} group was presented for 8 times. ERP were recorded during the 3^{rd} stage of the experiment. Another 16 novel shapes that have never been presented joined in the randomized sequences of presentation with the shapes from the 1^{st} and 2^{nd} groups. There were 64 trials ERP were collected in each condition for further analysis.

Results and Discussion

In Part I, we collected 42 subjects including 28 women and 14 men with a mean age of 40 ±15.4 years. Paired t-test was performed to examine the effect of the automatic versus control processes. It took longer to complete the "structured-organized" task (mean duration: 17.1 ± 3.1 sec) than to complete the "randomized-disorganized" task (mean duration: 15.54 ± 3.54 sec) with a statistic significant difference (p = 0.00002). The mean scores (correct – omission – commission) were lower (p = 0.00569) with "structured-organized" task (6.6 ± 4.3) than with "randomized-disorganized" task

(7.4±3.8).

In the ERP study, there are in total 20 normal subjects recruited, including 8 men and 12 women with an average age of 26 ± 7.3 years-old. The three conditions had similar waveforms especially the early components (Fig. 1) while their topographic mappings varied in the spatial distribution (Fig. 2A, B, C). At about 150 ms, all three conditions showed occipitoparietal activaties but at around 240 ms the differentiation appeared. In the well-memorized targets (1st group), inducing more automatic processing, the activities were mainly over the bilateral parietal cortexes more on the right side (Fig. 2A). However, in those implicitly learned targets (2nd group) some frontal activities appeared with persistent parietal activities (Fig. 2B). Furthermore, for those targets de novel that evoked highest control process among all the other (Fig. 3C). Brain responses to those well-memorized targets and to those implicitly learned are also different. The difference may be seen in the right parietotemporal area (Fig. 3C).

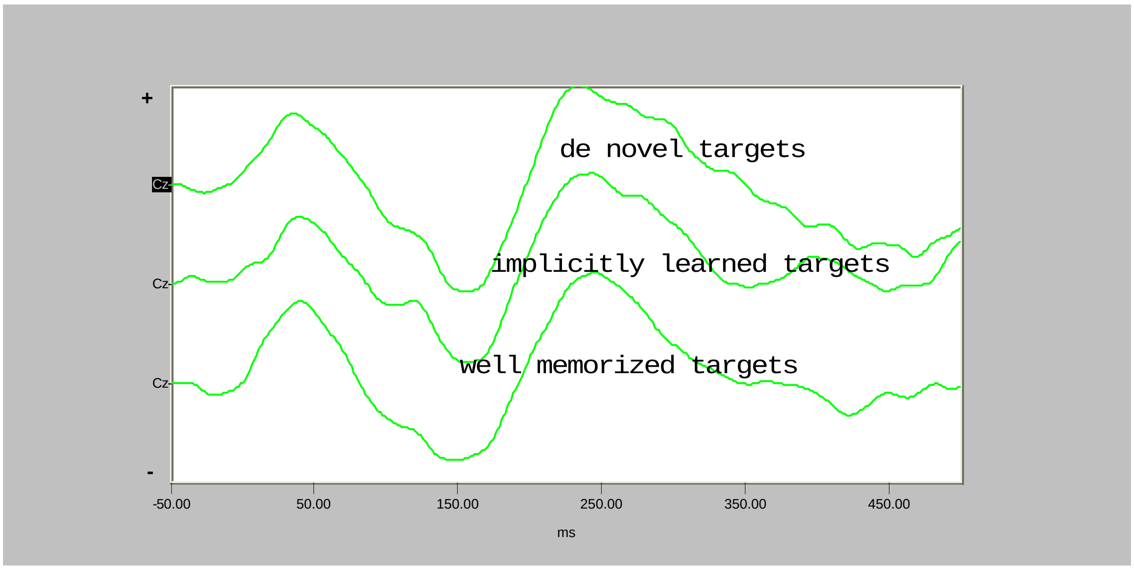

Fig. 1. The waveforms from all three conditions are similar especially in the early components such as N150 ms while slightly different in the waveforms of the late component. The waveforms were taken from grand average of 20 cases at Cz position.

That the duration to complete the “randomized-disorganized” task is longer than that to complete the “structured-organized” task seems paradoxical at the first glance. Since the former is more “controlled” and the later is more “automatic” and the “controlled process” should consume more brain resource than its “automatic” counterpart. Thus we might be tempted to assume that the “controlled process” took longer duration to complete its “randomized-disorganized” task. However, the “controlled process” might recruit more than necessary resource to overcome the challenge. Hence, enhanced performance may be observed in the “controlled process”. This is further confirmed by the fact that the correct rate is higher with the “controlled process”.

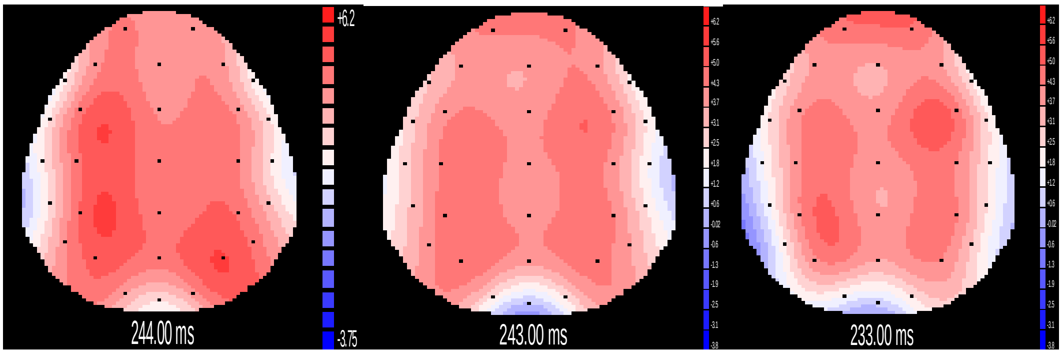

Fig. 2 A. The left map was from condition one, the automatic process with well memorized targets, showing that the major activities at P240 were from centroparietal area more prominent on the left side. 2B. The middle map was from condition two, the automatic-controlled process with implicitly learned targets, showing frontal activities in addition to the parietocentral activities. 2C. The right map was from condition three, the controlled process, with de novel targets, showing even stronger frontal activities.

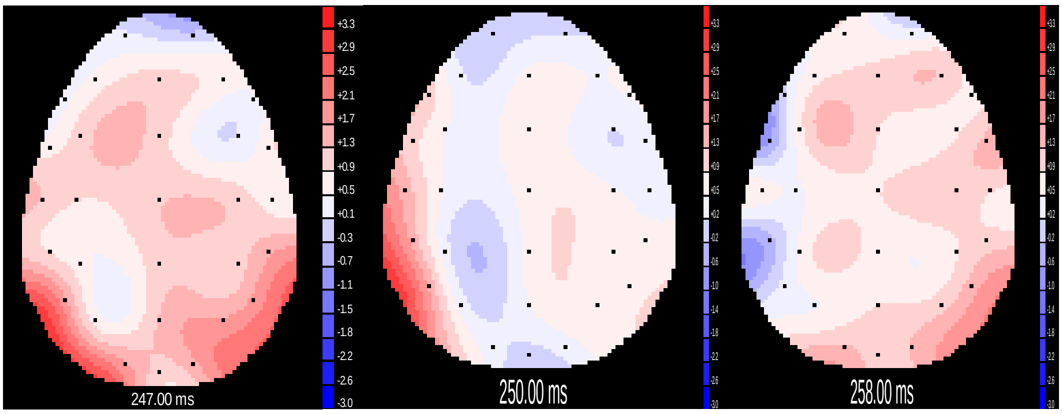

Fig. 3A. The left map is a t-map from condition 1 versus 4, the middle map is a t-map from condition 2 versus 4 and the right map is a t-map from condition 1 versus 2. The difference of response to presented and none-presented targets mainly in the left middle to posterior temporal areas related to picture storage. The negative frontal activities were also displayed although did not reach statistic significance.

The ERP mappings provided spatial information of the brain response in “automatic” versus “controlled” process. During recognition phase, the well-memorized targets were processed more “automatically” while the more implicitly learned targets or de novel targets required more resource from the frontal regions.

In conclusion, the observation in this study is compatible with the notion that the "controlled process" is more anterior while the "automatic process" is more posterior in locations.

References

Moscovitch, M. (1994). Cognitive resources and dual-task interference effects at retrieval in normal people: The role of frontal lobes and medial temporal cortex. *Neuropsychology, 8*, 524-534.

Moscovitch, M. & Winocur, G. (1995). Frontal lobe, memory, and aging. *Annals of New York academy of Sciences, 769*, 119-150.

Toth, J. P., Reingold, E. M., & Jacoby, L. L. (1994). Toward a redefinition of implicit memory: Process dissociations following elaborative processing and self-generation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 290-303