

Name	YU Hongtao
------	------------

学位論文の要旨

Abstract of Thesis

研究科 School	ヘルスシステム統合科学 Interdisciplinary Science and Engineering in Health Systems
専攻 Division	ヘルスシステム統合科学 Interdisciplinary Science and Engineering in Health Systems
学生番号 Student No.	78501204
氏名 Name	YU Hongtao

学位論文題目 Title of Thesis (学位論文題目が英語の場合は和訳を付記)

Study on Benefits of Semantically Audiovisual Interaction on Unisensory Working Memory

(視聴覚意味的相互作用が単感覚作業記憶に与える影響に関する研究)

学位論文の要旨 Abstract of Thesis

In daily life, human is often surrounded by stimuli from different sensory modalities (e.g., auditory, visual, tactile). To better master the external situation, human brain must integrate different sensory signals to sufficiently perceive the external environment. Especially, it must be noted that approximately 80% information is derived from auditory and visual channels. The ability to integrate the visual and auditory signal to a complete and coherent cognition is highly depending on audiovisual integration (AVI). It is worth noting that AVI not only facilitates the instant perception performance but also facilitates subsequent cognitive performance. Image that you must keep the phone number of a new friend in your mind. Memory encoding process will be facilitated if this friend writes the number while repeat the number using friend's own voice or suppressed when the friend writes the number while making an irrelevant joking. Although evidence had been showed that visual working memory retrieval can be accelerated by previous semantically congruent AVI, it remains argued that whether faster memory retrieval was contributed by a coherent multisensory representation or modality-specific unisensory representation. Considering the multisensory evidence indicated that coherent multisensory representation formation was contributed by semantically congruent AVI. Early multisensory studies reported that benefits of coherent multisensory representation for unisensory perception performance were asymmetric. Less effective auditory perception performance can receive more multisensory benefits compared with visual perception performance. Some studies also indicated the perception asymmetric performance can also modulate subsequent cognitive processing. Therefore, one possible research plan for exploring the unresolved question was investigating the unisensory (i.e., visual and auditory) working memory performance under different multisensory memory encoding environments. The main aim of this present thesis was to investigate how semantically audiovisual interaction differentially modulate subsequent unisensory working memory performance.

In part 1, we investigate whether semantically congruent AVI during the encoding stage of short-term memory can differentially modulate subsequent unisensory visual and auditory short-term memory performance by applying a delayed matching-to-sample paradigm (DMS). The reaction time

results revealed significantly faster unisensory short-term retrieval performance under the semantically congruent audiovisual encoding condition. The present study suggested that coherent multisensory representation formation might be optimized by semantically congruent multisensory integration with modal-based attention in memory encoding, and can be rapidly triggered by subsequent unisensory memory retrieval demands. For exclusively accelerated auditory short-term retrieval, we suggested that coherent multisensory representation formation is strengthened by a semantically congruent visual stimulus that is not the attention focus during the memory encoding stage. Importantly, during the memory retrieval stage, a less effective auditory stimulus can trigger optimized multisensory representation, thereby facilitating rapid memory retrieval processing. Especially, it must be noted DMS was widely used in previous short-term memory as well as working memory studies. To further evaluate the possibility that unisensory memory retrieval was also involved in working memory but not limit to short-term memory, we also tentatively evaluate the result reliability under three interference condition: distractor, interruption and no interference. For the interruption condition, the reaction time results revealed a significant difference in visual working memory retrieval between semantically congruent bimodal memory encoding and unimodal memory encoding. These results indicates that semantically congruent bimodal encoding accelerates the unisensory short-term memory and working memory retrieval.

In part 2, based on the part 1, we further investigate whether the interaction benefits between semantically congruent AVI and top-down attention can further modulate the subsequent unisensory visual and auditory working memory retrieval performance. The results reconcile and extend previous multisensory working memory studies by demonstrating that semantically congruent bimodal presentation with divided-modality attention can accelerate subsequent unisensory working memory retrieval, especially less effective auditory working memory retrieval. This result indicated that sufficient semantically congruent bimodal presentation (e.g., divided-modality attention) not only facilitates immediate behavioral perceptual performance but can also strongly impact subsequent unisensory working memory performance. Moreover, compared with insufficient multisensory integration (e.g., modality-specific selective attention), sufficient multisensory integration (e.g., divided-modality attention) requires more resources for an individual to fully encode and integrate visual and auditory information and maintain a robust multisensory representation, leading to fewer available resources for subsequent unisensory working memory retrieval. Especially, we conduct a control experiment to evaluate whether participants remember the visual or auditory stimulus by using verbal naming method. In lined with our previous experiment result, the result of control experiment also revealed a faster auditory memory retrieval under the semantically congruent AVI with divided-modality attention condition, indicating the verbal naming effect was not an important factor for faster auditory memory retrieval, one possibility we tentatively suggested that divided attention resource to two modalities might be led to sufficient multisensory integration, and then lead to robust multisensory representation formation.

In part 3, based on the part 2, we further investigate whether interaction between semantically congruent AVI and top-down attention can differentially modulate the unisensory visual and auditory working memory performance by affecting the memory encoding or retrieval stage. The first experiment evaluates whether unisensory working memory retrieval was benefiting from semantically congruent AVI. The results only found a weak significant difference for auditory

Name	YU Hongtao
------	------------

working memory retrieval under the semantically congruent and incongruent multisensory retrieval condition. And then, the second experiment evaluate whether unisensory working memory retrieval was not only benefit from the multisensory retrieval benefits but also can benefit from the multisensory encoding benefits. For visual working memory retrieval, significantly faster reaction time was found when semantically congruent audiovisual pairs were presented during the memory encoding and retrieval stage of working memory, indicating the coherent multisensory representation formation was facilitated by semantically congruent audiovisual encoding, and then visual probe trigger the multisensory representation even under the task-irrelevant, auditory stimulus interference condition. For auditory working memory retrieval, faster memory retrieval was only found in semantically congruent audiovisual encoding condition, it is reasonable to assume that a coherent, robust multisensory representation was constructed during semantically congruent multisensory memory encoding because of task irrelevance, but semantically congruent visual stimuli provide more redundant information. And then, during the working memory retrieval stage, a less effective auditory stimulus can trigger optimized multisensory representation and then achieve rapid memory retrieval processing.

In conclusion, first, we found that unisensory working memory retrieval (i.e., especially auditory modality) can be accelerated by previous semantically congruent AVI, indicating the possibility that coherent multisensory representation formation was contributed by semantically congruent AVI. Further, we found semantically congruent bimodal presentation with divided-modality attention can accelerate subsequent unisensory working memory retrieval, especially less effective auditory working memory retrieval, indicating the possibility that multisensory representation formation strongly depends on the sufficient attention resource. Finally, we found auditory memory retrieval unisensory memory retrieval can gain more multisensory benefits from memory encoding stage but not retrieval stage, indicating that memory retrieval stage might depends more on the extent to which the probe information overlaps the previous encoded information. Especially, a less effective auditory probe can trigger the coherent multisensory representation and then achieve rapid memory retrieval processing whatever the semantic information provided by a task-irrelevant visual stimulus was congruent or incongruent.