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研究課題名（和文）Remembering the dear past - how do emotions modulate the neural substrates of autobiographical memory recall?

研究課題名（英文）Remembering the dear past - how do emotions modulate the neural substrates of autobiographical memory recall?

研究代表者

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研究成果の概要（和文）：自伝的記憶（AM）の想起は、二つの段階から構成されると考えられる。あるテーマ（例、「ローマへの旅行」）に関する記憶を探索した上で、次は詳細かつ具体的な情報を収集し（例、「コロシアムで過ごした午後」）その経験を再体験する。本研究では、脳活動イメージング実験を実施し、これら二つの段階を担う脳神経基盤を調べた。その結果、AMプロセスにはさまざまな脳領域の相互作用から成ると明確になった。特に、背外側前頭前野・腹内側前頭前野、ならびに海馬および後頭内側皮質は重要な役割を担っていることが示された。なお、本研究下で実施した実験は、当機構がヒトを対象とした研究に関する規定を厳守して行われた。

研究成果の学術的意義や社会的意義
人は日常の中で過去に経験した出来事を振り返り、その記憶に基づいて未来を想像し、行動を決定する。本研究は、自伝的記憶を想起する脳内過程に着目し、機能的MRI（fMRI）とネットワーク解析を用いてそれらの過程を担っている脳内ネットワークの一部分を明らかにした。ネットワーク解析を活用することにより、脳部位が同時活動しているだけでなく、どの脳部位がどの脳部位に、どの程度の影響を引き起こしていることが分かり、脳内の階層構造が明らかになる。
加齢に伴う認知機能の最も顕著な変化としては記憶機能の低下があげられる。本研究成果は、将来的に記憶機能を修復及び強化するための新しいアプローチの開発に資すると期待できる。

研究成果の概要（英文）：Autobiographical memory (AM) retrieval is typically conceptualized as consisting of two phases. During the initial search phase, a memory that fulfills a given criterion (e.g., trip to Rome) is sought for, whereas in the subsequent elaboration phase, details are retrieved (e.g., an enjoyable afternoon spent touring the Colosseum), enabling one to relive the original experience. Here, we examined the neural mechanisms supporting these two phases by collecting and analyzing neuroimaging data. Overall, results indicated that AM processes involve the interaction of different brain regions, most prominently the dorsolateral and ventromedial prefrontal regions, as well as the hippocampus and the posterior midline cortex. Most importantly, they highlighted the importance of employing network analysis to obtain an in-depth systems-level understanding of human memory function. All experiments were performed strictly in accordance with our institute's bylaws regarding human subject research.

研究分野：Cognitive neuroscience

キーワード：episodic memory　autobiographical memory　functional MRI　dynamic causal modeling

様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９（共通）

１．研究開始当初の背景

Episodic memories of personal events – i.e., autobiographical memories (AMs) – are the trove of experiences that shape our daily life attitudes, preferences and decisions, determining to a great extent who we are and how we relate to the people around us. Such memories are associated with vivid imagery of the recollected event (*what*) and characterized by its spatial and temporal contexts (*where/when*), often colored by the emotions experienced during the occurrence of the event. AM retrieval is typically conceptualized as consisting of two phases. During the initial search phase, a memory lead that fulfills a given criterion (e.g., “trip to Rome”) is sought for, whereas in the subsequent elaboration phase, more details are retrieved (e.g., “an enjoyable sunny afternoon spent touring the Colosseum”), enabling one to relive the original experience. Emotions play a particular important role in AM processes; past research has consistently shown that AMs with greater emotional value are recalled more vividly and frequently than neutral memories. Nevertheless, the human brain mechanisms underlying such processes still remain largely unknown. Several neuroimaging studies have pointed to the existence of a large network associated with AM retrieval, which spans over the prefrontal cortex, posterior midline cortex, angular gyrus, medial and lateral temporal lobes, including the hippocampus (HPC) and oftentimes the amygdala. Though it is well established that the HPC has a fundamental role in memory encoding processes, it is much less clear what exact functions it plays during the retrieval of AMs, in coordination with the other brain regions in that network, most prominently the ventral prefrontal cortex (vmPFC), and especially when involving emotional AMs.

２．研究の目的

The large goal of the current research project was first and foremost to obtain a mechanistic understanding of how the brain regions within that large network interact with one another during AM retrieval processes. First, in the context of emotional AMs, we focused in the triadic network formed by the HPC, vmPFC and amygdala. Though it has been shown that these 3 brain regions co-activate during the retrieval of emotional AMs, little is known about how they interact during the AM elaboration phase, when the emotions experienced during the original event are likely to be restored in one form or another. More specifically, our goal was to understand the directions and the magnitudes of the influences exerted by one region in another during the elaboration of emotional AMs involving different types of valence (positive, neutral, negative) and levels of emotional intensity (low, high). Such analysis should reveal the underlying hierarchical organization connecting those regions with regard to those two dimensions (valence, emotional intensity). Second, we examined the patterns of brain activity elicited during the elaboration of emotional AMs with respect to the valence dimension, i.e., are the patterns stable enough across individuals to enable the correct inference of the valence of the recalled memory? Last, we looked at a much larger portion of the AM retrieval network and examined the interactions taking place during the AM search phase, when people search for an appropriate memory fulfilling a given criterion.

３．研究の方法

In the current research project, we collected brain activity data from healthy participants using functional MRI. Towards the goal of unraveling the interactions between brain regions during the different phases of AM retrieval, we analyzed the neuroimaging data by employing a network analysis technique called dynamic causal modeling (DCM) (Friston, Harrison, & Penny, 2003). The advantage of DCM over other network analysis techniques resides in the fact that it allows one to make principled inferences regarding the directions and magnitudes of the influences exerted by one brain region in another, which can be interpreted as reflecting the underlying flow of information among brain regions. To examine fMRI patterns of brain activity, we relied on data-driven analytical techniques largely grouped under multivariate pattern analysis (MVPA) (Haynes & Rees, 2006).

４．研究成果

(1) Results from the DCM analysis based on the data collected during the elaboration of emotional AMs revealed that during the elaboration of autobiographical memories, the vmPFC drives the activity in the hippocampus (Nawa & Ando, 2019). Moreover, when participants recalled memories associated with high emotional intensity or that elicited greater positive affect, its influence on hippocampal activation increased. These results suggest a specific double role of the vmPFC during the elaboration of personal memories, in line with two accounts of vmPFC function, namely, the integration and encoding of memory schemas and the construction of affective responses from conceptual information, placing the vmPFC in the center of the network supporting episodic memory processes.

(2) Results from the MVPA based on the data collected during the elaboration of emotional AMs showed that it is possible to infer the valence of the recalled memory (positive, negative) based on the data contained in a single fMRI volume above chance, for both the within (81%) and across participants (62%) setting (Frid, Manevitz, & Nawa, 2019). These results indicate that there are commonalities in the patterns of brain

activity that are associated with the valence of the recalled memory across individuals.
(3) Results from the DCM analysis based on the data collected during the search of AMs - when people attempt to retrieve memories from the personal past upon receiving a verbal cue – revealed the engagement of a large network of brain regions (Nawa & Ando, 2020). Such a network was primarily driven by the dorsolateral prefrontal cortex (dlPFC), the vmPFC and a region in the posterior midline cortex. Moreover, the results showed that when participants were successfully able to retrieve a memory upon being cued, there was a disengagement of the dlPFC and vmPFC, an up-modulation of the vmPFC and angular gyrus by the hippocampus, combined by a general inhibition of all other regions by the angular gyrus.

Overall, the results indicated that different stages of AM retrieval involve the complex interaction of various brain regions. Most importantly, the results highlight the importance of employing network analysis to obtain an in-depth systems-level understanding of human memory function.

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５．主な発表論文等

〔雑誌論文〕　計2件（うち査読付論文　2件／うち国際共著　0件／うちオープンアクセス　1件）

１．著者名 Norberto Eiji Nawa and Hiroshi Ando	４．巻 189
２．論文標題 Effective connectivity within the ventromedial prefrontal cortex-hippocampus-amygdala network during the elaboration of emotional autobiographical memories	５．発行年 2019年
３．雑誌名 NeuroImage	６．最初と最後の頁 316-328
掲載論文のDOI（デジタルオブジェクト識別子） http://doi.org/10.1016/j.neuroimage.2019.01.042	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 Norberto Eiji Nawa and Hiroshi Ando	４．巻 Early view
２．論文標題 Effective connectivity during autobiographical memory search	５．発行年 2020年
３．雑誌名 Brain and Behavior	６．最初と最後の頁 e01719
掲載論文のDOI（デジタルオブジェクト識別子） https://doi.org/10.1002/brb3.1719	査読の有無 有
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 －

〔学会発表〕　計4件（うち招待講演　0件／うち国際学会　4件）

１．発表者名 Norberto Eiji Nawa
２．発表標題 In search of my past: Effective connectivity during autobiographical memory search
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４．発表年 2019年

１．発表者名 Norberto Eiji Nawa
２．発表標題 vmPFC modulates hippocampus during the elaboration of positive/emotional autobiographical memories
３．学会等名 Organization for Human Brain Mapping (OHBM) Annual Meeting（国際学会）
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４．発表年 2018年

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２．発表標題 Judgments of experienced emotional intensity distinctively modulate nodes of the autobiographical memory network during the search and elaboration of memories
３．学会等名 47th European Brain and Behaviour Society Meeting (EBBS)（国際学会）
４．発表年 2017年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考