Олимпиада для студентов и выпускников – 2017 г.

Направление: «Психология»

Профиль:
«Когнитивные науки и технологии: от нейрона к познанию» КОД - 080

Время выполнения задания – 180 минут, язык: русский/English

1. Вам предложена короткая научная статья:
Botvinick, M., Nystrom, L. E., Fissell, K., Carter, C. S., & Cohen, J. D. (1999). Conflict monitoring versus selection-for-action in anterior cingulate cortex. Nature, 402(6758), 179-181.
В этой статье от Вас скрыта авторская аннотация.
Внимательно прочитайте статью и напишите краткую аннотацию (abstract) на 150-250 слов на русском языке. В аннотации необходимо отразить основную *проблему исследования*, ключевые *экспериментальные манипуляции*, главные *результаты* и предлагаемую авторами *теоретическую интерпретацию.*

2. Please, suggest your own interpretation of the results described below. Your answer should be in English.

In 1990, Stanislas Dehaene with colleagues discovered an effect, which gave rise to a substantial body of research. The participants in their experiments performed a very simple task. They were instructed to perform odd versus even classification of target numbers (from 0 to 9) by using their right and left hands to press one of two assigned keys. For half of the subjects, the left hand was assigned for odd numbers and the right hand for even numbers, and for the other half vice versa. The main finding was that the participants surprisingly produced faster responses to the smaller numbers with their left hand and to the larger numbers with their right hand. How would you explain this result? What would be your prediction, if participants responded to the target numbers not with hand responses, but with eye movements to the left or to the right from the central fixation point?"

3. Предложите схему экспериментального исследования для проверки нижеследующих предположений. Для этого нужно подробно описать процедуру эксперимента, стимульный материал, а также предполагаемые результаты.

Один из основных споров в когнитивной психологии внимания касается вопроса о том, на каком этапе происходит отбор релевантной информации для дальнейшей обработки. Согласно теориям ранней селекции, отбор происходит достаточно рано: на этапе анализа физических признаков. Согласно теориям поздней селекции, отбор происходит уже стадии семантического анализа поступающей информации. Есть и "компромиссное" предположение, выдвинутое в рамках теории перцептивной загрузки. Согласно этой теории, локус селекции зависит от общей загрузки системы переработки информации (то есть, от количества обрабатываемых стимулов и степени сложности задачи). Если загрузка невелика, то отбор происходит поздно, так как у системы переработки информации имеются дополнительные "мощности" для анализа нерелевантной информации. В случае перегрузки системы, отбор происходит рано, поскольку анализ нерелевантной информации не является целесообразным. Необходимо экспериментально проверить предположение о роли перцептивной загрузки в формировании локуса селекции информации.

Conflict monitoring versus selection-for-action in anterior cingulate cortex

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Abstract hidden

Subjects performed a version of the flanker task[9] in which they were asked to indicate by button-press the orientation of a briefly presented left- or right-facing arrow. The target arrow was always flanked by a set of distractor arrows, two on each side. On compatible trials, these pointed in the same direction as the target arrow (for example, <<<<<); on incompatible trials, they faced in the opposite direction (for example, <<><<).

The flanker task involves both conflict and selection-for-action, in particular on incompatible trials. On these trials the combined influence of the target and flankers leads to conflict in the form of competition between correct and incorrect responses, an effect that is reflected in prolonged reaction times[9–11]. At the same time, attending to the target but not the flankers calls for selection-for-action, a mechanism that according to A. Allport, the term's originator, "can selectively designate a specified subset of the available, and potentially relevant, sensory information to have control of a given effector system, and can selectively decouple the remainder from such control"[12].

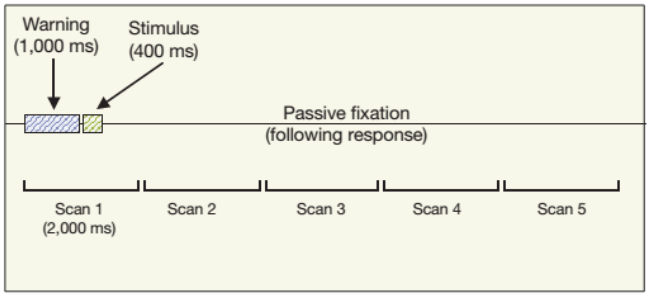

Figure 1 Relative timing of stimulus presentation and scan acquisition.

Our first prediction, based on the conflict-monitoring theory, was that ACC activation would be greater on incompatible trials, as this is where conflict is greatest. However, to adjudicate clearly between the two theories of ACC function, we turned to a second prediction, based on a phenomenon we refer to as the Gratton effect.

Gratton *et al.*[13] discovered that the balance between conflict and selection-for-action on any given trial in the flanker task depends on the compatibility of the preceding trial. Specifically, they showed (based on reaction time data) that the distracting effect of the flankers is weaker on trials that follow incompatible trials than on trials that follow compatible ones. In effect, the occurrence of an incompatible trial leads to a strengthening of selection-for-action, reducing the influence of the flankers during the subsequent trial.

The most interesting implications of the Gratton effect relate specifically to incompatible trials. For purposes of analysis, we divide these trials into two categories: those that follow compatible trials (here labelled cI), and those that follow incompatible ones (iI). Owing to the Gratton effect, these two groups of trials involve very different proportions of selection-for-action and conflict. Incompatible trials that follow other incompatible trials (iI trials) involve relatively strong selection-for-action and, as a result, diminished flanker-induced conflict. Conversely, incompatible trials coming after compatible ones (cI trials) involve relatively weak selection-for-action and, thus, more flanker-induced conflict.

These observations prompt the two theories of ACC function to make opposite predictions about brain activation during cI and iI trials. The conflict-monitoring theory predicts that ACC activation should be greater on cI trials, when conflict is at its highest. The opposing selection-for-action theory predicts that activation should be greater on iI trials, when there is stronger selection-for-action.

No task yet studied has been found to engage the entire ACC, leaving open the possibility of functional heterogeneity within the region. Our predictions therefore specifically relate to the portions of ACC to which a selection-for-action role has previously been ascribed. These centre on a region anterior to the plane of the anterior commissure, posterior to the genu of the corpus collosum and often extending into the cingulate sulcus.

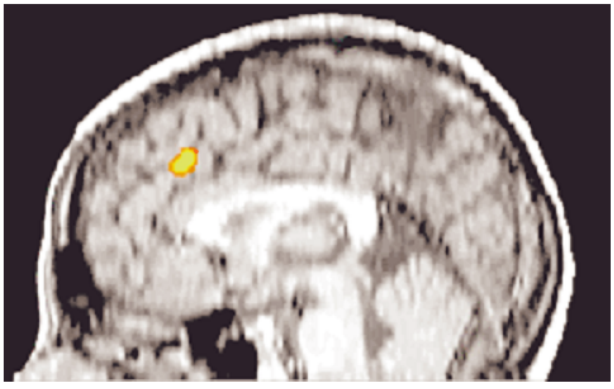

Figure 2 Location of the ACC area displaying greater activity on incompatible than compatible trials and on cI than iI trials. The area shown represents the overlap of regions identified in independent ANOVAs (see Methods), each using a significance threshold of $P = 0.01$. Peak F values for both regions fell within the area depicted (scan × trial-type interaction: $F = 17.16$, coordinates $x = -2$, $y = 28$, $z = 31$; scan × previous trial-type interaction: $F = 5.2$, coordinates $x = -2$, $y = 31$, $z = 29$). Areas outside the ACC showing an effect of current trial type with a peak F equal to or greater that observed in the ACC included right inferior parietal lobule (BA 40) and left anterior insula. Areas showing an effect of previous trial type on incompatible trials with a peak F equal to or greater to that observed in the ACC included left dorsolateral prefrontal cortex (BA 9/46), bilateral postcentral gyrus, and bilateral inferior parietal lobe (BA 40, with extension into BA 39 and 22 on the left).

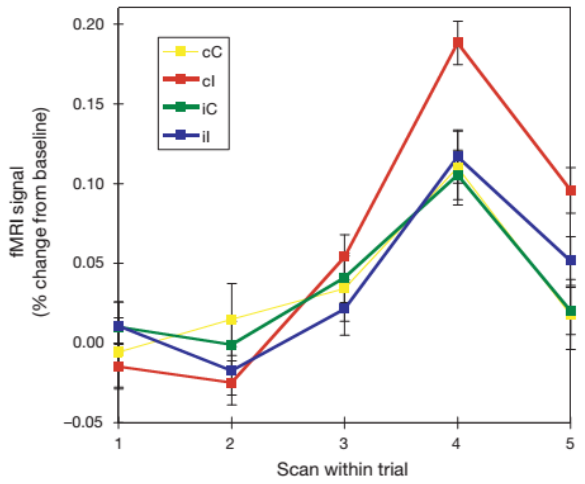

Figure 3 Time-course of activity within the region shown in Fig. 2. Like incompatible trials, compatible trials are displayed according to previous trial-type (cC: previous trial-type compatible; iC: previous trial-type incompatible). fMRI signal is based on the group and area average, expressed as percent change from baseline (average scan-one activation). Error bars are based on the s.e.m. Planned comparisons confirmed that peak activation was higher on incompatible trials than compatible trials ($M = 0.15\%$ and 0.11%, one-tailed $t(7) = 2.32$, $P < 0.03$) and higher for cI trials than iI trials ($M = 0.18\%$ and 0.12%, one-tailed $t(7) = 2.39$, $P < 0.025$).

Functional magnetic resonance imaging (fMRI) data collected as subjects performed the flanker task unambiguously confirmed both predictions of the conflict-monitoring hypothesis. The use of event-related scan acquisition and long interstimulus intervals allowed us to trace the time-course of regional brain activation during the course of individual trials (Fig. 1). As anticipated on the basis of previous findings[7], activation within the ACC showed a response-related pattern, rising from a baseline at the time of stimulus presentation to a peak about 5 s later (consistent with the 5-s haemodynamic lag typically observed in fMRI experiments)[14]. Analyses revealed a region within the dorsal ACC (BA 32) where peak activation was greater during incompatible than compatible trials, and greater during cI than iI trials (Figs 2, 3). No area within the ACC showed the opposite pattern in either comparison.

Several additional findings further support the conflict-monitoring view. First, on compatible trials—unlike incompatible ones—peak ACC activation was not significantly affected by previous trial type (see Fig. 3). This result is consistent with the conflict-monitoring hypothesis, as compatible trials are unlikely to induce conflict, regardless of context. Importantly, when the data for compatible trials is considered alongside that for incompatible ones, it becomes clear that the difference between cI and iI trials is actually part of a larger pattern, involving an interaction between previous and current trial type. A confirmatory analysis (see Methods) showed this interaction to be present in the ACC to a significance level of $P < 0.001$.

Also informative is that, across subjects, the strength of ACC activation was strongly correlated with the severity of conflict. For each subject, we calculated the difference in reaction time between cI and iI trials, using this as a measure of the difference in conflict between these two trial-types. Analysis revealed a robust positive correlation between this index of conflict and the behaviour of the ACC, measured again as the difference between cI and iI trials ($r^2 = 0.66$, $P < 0.01$).

Finally, convergent evidence for the conflict-monitoring theory is provided by the results of a companion study in which the ACC showed comparable behaviour in a different behavioural task (the Stroop task)[15,16].

Although our findings challenge the prevailing view of ACC function, note that the conflict-monitoring account does not rule out an influence of the ACC on selection-for-action. Indeed, behavioural, anatomical and psychophysiological evidence indicates that conflict monitoring may act as a source of feedback to mechanisms involved in recruiting attention, serving to indicate the need for increased top-down control on information processing[6]. An important goal of subsequent studies will be to evaluate this potential relationship between conflict monitoring and cognitive control, as well as to investigate the relation between the ACC and other brain areas implicated in executive function. □

Methods

Subjects and task

Subjects were eleven neurologically normal, right-handed volunteers (seven male, ages 21–32). Stimuli were generated using PsyScope software[17] on a Macintosh computer, and appeared on a back-projection screen mounted inside the scanner bore, which subjects viewed through a mirror. Subjects were instructed to foveate a centrally-located fixation point throughout the task. This point (an asterisk) brightened 1,000 ms before the appearance of the target stimulus. Target stimuli (40% compatible, 60% incompatible in pseudorandom order) appeared just above the fixation point for 400 ms with an interstimulus interval of 10 s. Subjects used their right hand to respond, and were instructed to respond to a left-facing target by pressing a button beneath their index finger, and to a right-facing target by pressing a button beneath their middle finger.

Behavioural data reflected both the basic compatibility effect and the sequential dependency effect reported by Gratton *et al.*[13]. Reaction times were longer for incompatible trials than for compatible ones ($M = 790$ and 523 ms, $t(10) = 4.86$, $P < 0.001$), and the flanker effect (difference between incompatible and compatible conditions) was larger for trials following compatible than incompatible trials ($M = 290$ and 243 ms, $t(10) = 3.97$, $P < 0.005$). cI trials were slower than iI trials for eight of the eleven subjects. Errors made up two percent of trials, and were most common on cI trials, consistent with the Gratton effect and ruling out a speed-accuracy tradeoff.

Image acquisition and analysis

Images were acquired with a 1.5-T GE Signa whole-body scanner with a standard head-coil. Thirteen axial slices (with 3.75[3] cm voxels) were obtained parallel to the AC-PC line. Beginning with brightening of the fixation point, five consecutive 2-s functional scans were acquired on each behavioural trial, using a two-shot spiral T2*-weighted sequence[18], with TR 1,000 ms, TE 35 ms, flip angle 55° and field of view 24 cm. Structural images were obtained with a standard T1-weighted pulse sequence.

Because our second fMRI prediction was intended to apply only in the presence of the Gratton effect, we decided before running the experiment that data would be analysed only for subjects whose behaviour on incompatible trials showed the Gratton effect (cI responses slower than iI responses; eight of our eleven subjects). Only correct trials were included, given the previously observed association of errors with ACC activation[7]. Data from individual participants were subjected to a voxelwise within-block linear detrending and between-block, subtractive mean normalization. Images were co-registered to a common reference structural MRI scan using a 12-parameter automated algorithm[19]. Images were then smoothed with an 8-mm full width at half maximum, three-dimensional gaussian filter to accommodate individual differences in anatomy.

To identify areas showing an effect of current trial-type, an analysis of variance (ANOVA) with current trial-type, previous trial-type and scan-within-trial as factors was run on each voxel, and voxels were identified that showed an interaction between scan and current trial-type. To identify areas that were differentially activated during cI and iI trials, we ran a separate ANOVA involving only incompatible trials with scan-within-trial and previous trial-type as factors, and identified voxels that showed an interaction between scan and previous trial-type. In both analyses, we used an eight-voxel cluster-size threshold to correct for multiple comparisons[20]. Planned comparisons on peak activation were based on average activation across the regions identified by each ANOVA and their intersection. To confirm the presence of an interaction between current and previous trial-types, we performed a two-way ANOVA using the approach above, but focusing on data pooled from scans four and five to maximize sensitivity to task-related effects. This yielded a main effect of current trial-type and an interaction between current and previous trials-types, both appearing in an area of the ACC very similar to that identified in the primary analyses. Both effects survived a significance threshold of $P < 0.005$.

Received 19 April; accepted 23 August 1999.

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