Egocentric-updating during navigation facilitates episodic memory retrieval

Alice Gomez, Stéphane Rousset*, Monica Baciu

Q1 Laboratoire de Psychologie et Neurocognition [LPNC], CNRS UMR 5105, Université Pierre Mendès France, Domaine Universitaire de St Martin d’Hères, Bâtiment Sciences de l’Homme et Mathématiques, BP 47, 38040 Grenoble Cedex 9, France

ABSTRACT

Influential models suggest that spatial processing is essential for episodic memory [O’Keefe, J., & Nadel, L.
(1978). The hippocampus as a cognitive map. London: Oxford University Press]. However, although several types of spatial relations exist, such as allocentric (i.e. object-to-object relations), egocentric (i.e. static object-to-self relations) or egocentric updated on navigation information (i.e. self-to-environment relations in a dynamic way), usually only allocentric representations are described as potentially subserving episodic memory [Nadel, L., & Moscovitch, M. (1998). Hippocampal contributions to cortical plasticity. Neuropharmacology, 37(4–5), 431–439]. This study proposes to confront the allocentric representation hypothesis with an egocentric updated with self-motion representation hypothesis. In the present study, we explored retrieval performance in relation to these two types of spatial processing levels during learning. Episodic remembering has been assessed through Remember responses in a recall and in a recognition task, combined with a “Remember-Know-Guess” paradigm [Gardiner, J. M. (2001). Episodic memory and autonoetic consciousness: A first-person approach. Philosophical Transactions of the Royal Society B: Biological Sciences, 356(1413), 1351–1361] to assess the autonoetic level of responses. Our results show that retrieval performance was significantly higher when encoding was performed in the egocentric-updated condition. Although egocentric updated with self-motion and allocentric representations are not mutually exclusive, these results suggest that egocentric updating processing facilitates remember responses more than allocentric processing. The results are discussed according to Burgess and colleagues’ model of episodic memory [Burgess, N., Becker, S., King, J. A., & O’Keefe, J. (2001). Memory for events and their spatial context: models and experiments. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 356(1413), 1493–1503].

© 2009 Published by Elsevier B.V.

* Corresponding author. Tel.: +33 0 4 7682 5850; fax: +33 0 4 7682 7834.
E-mail address: Stephane.Rousset@upmf-grenoble.fr (S. Rousset).

1. Introduction

Data drawn from amnesic patients with hippocampal lesions and from the discovery of hippocampal “place cells”, have led to the assumption that episodic memory and spatial processing are linked (Holdstock et al., 2000; King, Burgess, Hartley, Vargha-Khadem, & O’Keefe, 2002; O’Keefe & Dostrovsky, 1971; O’Keefe & Nadel, 1978; Spiers, Burgess, Hartley, Vargha-Khadem, & O’Keefe, 2001; Spiers et al., 2001). To date, however, little is known about how they are functionally related and more specifically which spatial processing underlies Episodic Memory.

Episodic memory was originally described as the memory for information located in time and space. This definition emphasized the access to “what”, “when” and “where” information on the event. This definition of Episodic memory has greatly evolved since then. Tulving (2002) now considers that the subjective sense of re-experiencing an event, called autonoetic consciousness, is the hallmark of episodic memory. Autonoetic consciousness relies on the binding of the “what”, “where”, and “when” of the information learned (De Goede & Postma, 2008; Meiser, Sattler, & Weissen, 2008). To a larger extent, this ability allows one to mentally navigate backwards or project forward along something akin to a personal “movie” (Wheeler, Stuss, & Tulving, 1997).

Here, we distinguish three types of spatial representations, egocentric (i.e. code for static object-to-self relations), allocentric (i.e. code for static object-to-object relations) and egocentric updated with self-motion (i.e. code for self-to-environment relations in a dynamic fashion), that could be linked to long-term memory in different ways (for a recent review see Postma, Kessels, & van Asselen, 2008).

Due to permanent changes in the subjects’ localisation and orientation, the static or iconic-egocentric representations (King, Burgess, Hartley, Vargha-Khadem, & O’Keefe, 2002), are generally seen as inefficient for long-term memory storage of an episode. In contrast, allocentric representations are considered more stable, independent of subject movement (Burgess, Becker, King, & O’Keefe, 2001). Nadel and Moscovitch (1998), and O’Keefe and Nadel...
(1978) proposed that the hippocampus would be able to bind all
the neocortical representations related to an episode by providing
a spatial scaffold for the episode. This theory posits that episodic
memory relies on spatial knowledge acquired as a map, thus on
relations existing between objects (i.e. allocentric representations).
As previously mentioned numerous studies have reported a coin-
cidence of impairments in topographical and episodic memory fol-
lowing hippocampal lesions (Burgess, 2006; Holdstock et al.,
2000; Hort et al., 2007; King, Burgess, Hartley, Vargha-Khadem,
& O'Keefe, 2002; Spiers, Burgess, Hartley, Vargha-Khadem, &
O'Keefe, 2001; Spiers et al., 2001). Although, to our knowledge only two
studies have clearly focused their interest on allocentric and ego-
centric deficits in relation with episodic memory impairments
after hippocampal lesions (Holdstock et al., 2000; King, Burgess,
Hartley, Vargha-Khadem, & O'Keefe, 2002). These experiments op-
posed iconic-egocentric (i.e. visual pattern matching tasks) to a
shifted-view condition, and supported the idea that iconic-egocen-
tric representation cannot be proposed to functionally underlie
episodic memory. As acknowledged by its authors, the shifted-
view condition might have been concurrently solved using an allo-
centric processing or an egocentric-updated processing.

In fact, spatial memory cannot be reduced to only allocentric
and iconic-egocentric representations (Avraamides & Kelly, 2008;
van Asselen et al., 2006; Waller, Lippa, & Richardson, 2008). Behav-
iorial, electrophysiological and fMRI data suggest that it could be
possible to consider another type of representation involved in nav-
gitation (Burgess & O'Keefe, 1996; Farrell & Robertson, 1998; Magu-
ire et al., 2003; Mellet et al., 2000; Nardini, Burgess, Brechenridge,
& Atkinson, 2006; Wang & Spelke, 2000; Whishaw, McKenna, &
Maaswinkel, 1997). This egocentric updated with self-motion rep-
resentation would be automatically constructed from both ideote-
thic (i.e. sensory information extracted from stable stimuli) and
alotetic information (i.e. sensory information acquired through
self-movement). This representation would remain egocentric in
the sense that it uses a coordinate system centred on the observer.
Nevertheless, it would encode self-to-environment relations in a
dynamic fashion due to continuous vestibular, proprioceptive,
and visual flow inputs, during navigation.

Moreover, although episodic information of an event can be
simultaneously represented in an allocentric and an egocentric
way, allocentric representations alone cannot account for self-cen-
tred visuo-spatial re-experiencing, in a direct way (Burgess, Becker,
King, & O'Keefe, 2001). A translation from the allocentric reference
frame to an egocentric reference frame would be necessary. Craw-
ley and French (2005) explored the link between points of view
and autonoetic consciousness by using the “Remember-Know-Guess” paradigm (RKG) (Gardiner, 2001; Gardiner, Ramponi,
& Richardson-Klavehn, 1998). They observed that Remembered (R)
information induced viewer-centred recall, whereas Known (K)
information was independent of viewer perspective, like allocen-
tric relations. R information refer to event retrieved through an
“autonoetic consciousness” of the original event, a central feature
of episodic memory. Instead, K information induce no re-experi-
encing of the event and are related to the semantic memory. In a
similar vein, congruent body posture has been observed to facil-
itate access to and retention of remote episodic memories (Dijkstra,
Kaschak, & Zwaan, 2007). Thus, episodic memory appears to be
linked with viewer-centred recall.

We acknowledge that egocentric-updated information could
simply reflect the possible translation of allocentric information
representations into egocentric iconic ones. Nonetheless, we won-
dered if a memory of allocentric processing alone could account
for episodic memories or if egocentric-updated processing performed
during learning is crucial for re-instantiating an episodic memory.
Indeed, if iconic-egocentric representations do not underlie
long-term memory, it remains unclear in the literature which of these
last two spatial representations, allocentric or egocentric updated
with self-motion, plays a more important role for long-term epi-
sodic memory. The aim of this experimental study is to directly
compare these two types of spatial representation by testing
whether egocentric-updated processing helps subsequent episodic
remembrance more than allocentric processing alone.

To investigate this issue, we designed two experimental condi-
tions emphasizing either object-to-object processing (i.e. allocen-
tric) or dynamic self-to-environment processing (i.e. egocentric-
updated) by changing the spatial context-task performed during
incidental encoding of items into long-term memory. Free recall,
and recognition of item names were then measured 4 h later. This
global memory performance emphasized only the “what” compo-
nent of episodic memories. To strictly assess episodic memory, a
“Remember-Know-Guess” paradigm was used to insure that the
measured effects were associated with autonoetic consciousness
(i.e. R responses). An additional source-monitoring task was pro-
aposed after the recognition task. By evaluating memories of the
stimuli encoding context, this task provides further corroboration
on the effects measured through R responses. In the present study,
we attempted to disentangle two hypotheses describing the link
between episodic memory and spatial processing. The first hypo-
thesis that we will call the allocentric hypothesis, supposes that
allocentric representations are sufficient and essential for episodic
memory (Nadel & Moscovitch, 1998). The allocentric hypothesis
presumes that learning words while emphasizing allocentric rep-
resentation rather than egocentric updated with self-motion repre-
sentation facilitates retrieval performance, especially when related
to autonoetic consciousness (i.e. R responses). The second hypo-
thesis, that we will call the egocentric-updated hypothesis, predicts
the opposite pattern of results (i.e. retrieval facilitation in the ego-
centric-updated condition, especially for R responses). This
hypothesis does not exclude a potential functional implication of
the allocentric representation within the Episodic Memory.

2. Materials and methods

In the first part of the following procedure, participants learnt to
spatially process the environment layout then they spatially pro-
cessed the layout when it included test pictures (which were here
learnt incidentally). In the second part, 4 h later, they were unex-
pectedly tested on recall and recognition for the pictures alone
(and not on any of the spatial relations that appeared to be the test
in the first part).

2.1. Participants

Twenty-two undergraduate and graduate students in psychol-
ogy (1 male and 21 females), aged from 18 to 37 years (mean age of 22 years and 2 months) participated in the experiment for
course credit. They all gave written informed consent to the
experiment.

2.2. Stimuli

To capture the true dynamism of navigation while maintaining an
appropriate degree of experimental control, participants ac-
ESI:G

Please cite this article in press as: Gomez, A., et al. Egocentric-updating during navigation facilitates episodic memory retrieval. Acta Psychologica (2009),
doi:10.1016/j.actpsy.2009.07.003
Thirty-three 20 s-long 1st-person perspective movies were created including views of short navigation routes in the environment. Neither the movies nor the contextual snapshots contain the material-to-be-remembered.

2.3. Procedure

Each participant followed a procedure composed of three phases: training, study, and four-hours-delayed-test. From pilot studies, we designed two spatial tasks of equivalent complexity. Each task, which we will call “frame task”, is intended to maximize one or the other type of spatial processing during learning of the item-to-be-remembered. Processing conditions (i.e. Allocentric vs. Egocentric-updated) were manipulated during the study phase in a “within-subject” design.

2.4. Training phase

Participants were familiarised with five trials of each spatial frame task, without presentation of any items-to-be-remembered.

2.5. Allocentric frame task

To emphasize object-to-object processing, participants had to locate and establish relative positions between two objects by employing relative distance and direction terms.

An object static image is presented, and designated by the experimenter as the spatial goal object which will have to be reached during the probe screen presentation (see Fig. 2). Then, the probe screen (which will be used to present the item-to-be-remembered in the study phase) is presented during 15000 ms. In this condition, the probe screen is composed of four snapshots: A close-up view of the goal object, a close-up view of an object designated as the source object, and two contextual snapshots. Each of the contextual snapshots is designated as the context image (of the goal or of the source). The task was to indicate the position of the goal object relative to the source object. Crucially here, to enhance object-to-object processing and the use of map-like representations, no images contained enough information to solve the task via a direct visual strategy. Participants gave verbal categorical information on the relationships such as “on the left”, “to the top”, and “far from”. They sketched with a pointer on the source image the directional vector toward the goal object (see Fig. 2).

2.6. Egocentric-updated frame task

To emphasize self-to-environment processing, participants had to situate themselves in the environment according to a route movie and complete a pseudo-navigation between two locations.

A 1st-person-perspective movie is presented (see Fig. 2). Movies were always circuitous so that there was a shortcut that differed from the path taken in the movie. On the final view of the movie, the object presented is designated by the experimenter as the spatial goal object which will have to be reached during the probe screen presentation. Then, the probe screen (which will be used to present the item-to-be-remembered in the study phase) is presented during 15000 ms. In this condition, the probe screen is composed of two snapshots: a close-up view of the goal object (corresponding to the final view in the movie) and the initial snapshot of the movie. The close-up view is designated as the goal object. The initial snapshot of the movie is designated as the source view. This initial snapshot is a large view of the environment, thus it contains contextual information on the room. The task was to mentally produce shortcut navigation, from the initial view of the movie (i.e. the source view) to the final view of the movie (i.e. the goal object). Participants were asked to produce a self-centred navigation from the initial point of view of the movie to the final point of view of the movie. To assess task execution, participants gave verbal categorical information on their navigation, such as “I turn left”, “I walk straight”. They were free to sketch out their path while imagining it (see Fig. 2).

2.7. Study phase

Fourteen items-to-be-remembered were presented in each contextual spatial task condition. It is crucial for the experiment that the first static images and videos do not contain the pictures or names of the birds (which are to-be-remembered). They only gave
location information necessary to solve the frame tasks. Only the probe screen of each condition, composed of static pictures of the room with identical presentation characteristics, contained the birds’ names and pictures (see Fig. 2).

In each condition, participants were presented with the probe screens for a period of 15 s. In the probe screens the item-to-be-remembered was presented embedded in the goal object and participants are required to use the bird names rather than goal objects in their responses (verbal response example; egocentric-updated, “Walk straight, turn slightly to my left, and turn to my right to face the buzzard”; Allocentric, “Close, to the right and to the bottom of the buzzard”, also see Fig. 2). Otherwise the tasks were the same as in the training phase. To prevent any bias introduced by presentation order, the order of items was randomized and the frame task trial types were randomly interleaved. Assignment of experimental items to a learning frame task was counterbalanced across subjects.

Because there is only one environment, and because conditions are presented in an interleaved way, in a within-subjects design (i.e. the same participant saw movies of the environment and multiple pictures of it in a random order) participants were able to build a unique and detailed representation of the environment. General knowledge, on the elements constituting the environment and on their spatial arrangement, was progressively built during the training and study phases, and thus remained equal between conditions. This experimental design prevents a potential interpretation in terms of a more life-like presentation in one of the conditions, or in terms of differences between movies and pictures, as items are encoded during the probe screens only, which are equal on the level of similarity with real life.

2.8. Test phase

Episodic memory was assessed via two tests: 1) a recall test with a RKG paradigm, and 2) a two-part recognition test using both an RKG question and a source-monitoring test on each item. To test free recall, participants were asked to recall the names of birds they saw and named in the study phase. Participants then assigned a level of consciousness to each recalled word. Including an RKG paradigm within the recall task was important to assess the subjective feeling of autonoetic consciousness which simple recall does not address. Thus, as in the recognition test, participants could answer: (1) I “Remember” when I learned the word, and recollect some aspects, details of the episode (2) I “Know” that the word has been presented, but I cannot recollect or travel back in time; (3) I “Guess” but I am not sure about this word. Instructions explicitly referred to the elicited consciousness. Each answer had to be validated by an explanation to systematically check the cues used, as proposed by Gardiner (2001).

During the recognition test, 56-bird names were presented sequentially. Twenty-eight of the bird names were presented in the previous phase (14 in the egocentric-updated condition, 14 in the allocentric condition), 28 were new. New items remained constant across subjects. Each word appeared for 2000 ms. For each word, participants had to decide between previously cited possible answers (1), (2) or (3), and an additional answer (4) “New”, when the item was believed not to have been previously presented. For the source-monitoring part of this task, recognized words had to be classified as seen during the Egocentric-updated or Allocentric frame task condition. Participants were also allowed to specify that they could not give this information.

2.9. Experimental setup

Experiments were performed using the E-Prime 2.0 software (Psychological Software Tools, Pittsburgh, PA). During the learning phase participants stood in front of a PHILIPS 21-inch colour screen, placed 140 cm from the floor and located at a distance of 75 cm from the participants. During test phase participants sat in front of a laptop.

3. Results

As we expected an overall retrieval performance effect, and crucially in R responses, an ANOVA was conducted on the number of recalled, recognized and correctly source-monitored words, using...
the encoding frame task (Egocentric-updated condition vs. Allocentric condition) and the RKG response (R, K or G) as within-subject factors.

3.1. Recall data

There was a significant main effect of the frame task during learning: $F_{subject}(1, 21) = 15.05, p = 0.0008$; $F_{item}(1, 27) = 14.71, p = 0.0007$, in favour of egocentric-updated processing during encoding. Unsurprisingly, recall responses were mainly R ones: $F_{subject}(2, 42) = 13.85, p = 0.0000$; $F_{item}(2, 54) = 11.90, p = 0.0000$. We observed, furthermore, a significant interaction (see Fig. 3a) between frame task conditions and RKG procedure response type: $F_{subject}(2, 42) = 5.38, p = 0.008$; $F_{item}(2, 54) = 7.24, p = 0.001$. We cannot assert that this interaction gives a reliable supplementary result since the near floor performance on K and G responses induced heterogeneity of variances which might have artificially strengthened the interaction. However, planned contrasts ensured that this frame task effect was present for R responses, associated with autonoetic consciousness $F_{subject}(1, 21) = 11.61, p = 0.002$; $F_{item}(1, 27) = 13.81, p = 0.0009$.

3.2. Recognition data

After a four-hour delay, subjects remembered well enough for us to get significant results; the associated $d’$ was 1.09, with an average performance of 19.08 words correctly recognized out of 24. Although, the recognition measure was directly the number of correct responses. In fact, $d’$ could not be used to run our analyses or plot the results. False positives could not be assigned to one or the other condition since a new item did not refer either to an egocentric-updated learning condition nor to an allocentric learning condition. Significantly more words were correctly recognized in the Egocentric-updated than in the Allocentric condition $[F_{subject}(1, 21) = 6.72, p = 0.017$; $F_{item}(1, 27) = 8.40, p = 0.007]$. Most recognitions were assigned to an R response: $F_{subject}(2, 42) = 17.00, p = 0.0000$; $F_{item}(2, 54) = 34.75, p = 0.0000$. Again, a significant interaction between frame task conditions and RKG procedure response type was observed, but only in the by-item analysis (see Fig. 3b): $F_{subject}(2, 42) = 2.33, p = 0.10$; $F_{item}(2, 54) = 5.80, p = 0.005$. Planned contrasts on R responses ensured that this effect was indeed present for responses associated with autonoetic consciousness: $F_{subject}(1, 21) = 6.23, p = 0.02$; $F_{item}(1, 27) = 12.75, p = 0.001$. Contrary to R responses, there is no indication that there is an effect of learning frame task neither for K nor for G responses ($F < 1$).

Finally, as defined in the procedure, participants monitored the source of recognized items. There was a significant main effect of the contextual task during learning on the number of correctly source-monitored words: $F_{subject}(1, 21) = 8.28, p = 0.009$; $F_{item}(1, 27) = 6.52, p = 0.01$. Egocentric-updated source-monitoring with 3.5 words (SD = 0.38) was superior to Allocentric source-monitoring with 2.31 words (SD = 0.23). To ensure that no bias in the source-monitoring task was responsible for these results, we looked at false alarms related to each condition. We observed an equivalent mean number of false alarms from the Egocentric-updated and Allocentric frame tasks (1.50 and 1.54, respectively).

4. Discussion

This study assessed the effect of the spatial processing type engaged during encoding on the subsequent episodic retrieval. Two proposals have been compared, (a) the allocentric hypothesis asserting that object-to-object relations enhance episodic memory, and (b) the Egocentric-updated hypothesis asserting that episodic memory relies on self-to-environment relations updated during navigation. We asked whether successful episodic retrieval depends more on Allocentric or on Egocentric-updated representations during encoding.

Episodic memory was assessed using three tasks: recall, recognition, and source-monitoring, by means of an RKG paradigm. Our analyses were mainly focused on Remember judgments that reflect a state of autonoetic consciousness, characteristics of multidimensional bindings (i.e. “What”, “Where”, “When” binding). A source-monitoring task was added to the recognition task in order to obtain additional evidence on the circumstance of encountering the event, a specific subpart of episodic memory. To test the facilitation effect induced on episodic memory per se and not on spatial memory, performance was assessed on verbal items, embedded in a contextual spatial task during encoding, rather than on source recall of spatial characteristics. As predicted, items learned in the Egocentric-updated condition were retrieved better than those studied in the Allocentric condition. Using the RKG paradigm, we insured that this advantage was observed for the R responses of recall and recognition. These responses are phenomenologically associated with autonoetic consciousness. The study phase procedure operates on type and/or depth of processing differences. Due to the difference in the contextual information potentially enclosed in a video versus a static presentation, richness or depth of processing differences on the global context of the item-to-be-remembered (although not on the object itself)

![Fig. 3. Average number of items correctly recalled (a) and recognized (b), according to Remember, Know, and Guess responses, after learning items within a Egocentric-updated (black) or Allocentric (white) frame task. ** p < 0.01.](image)
must be addressed as a possible explanation of the results. Nevertheless, the experimental procedure was designed to limit a potential distinctiveness effect of the context, by using a unique environment across conditions (so that participants were able to build a unique and detailed representation of the environment). Moreover, the overall number of contextual objects visible within each complete trial was kept equivalent across conditions (with an average of 20 objects) so that conditions did not differ on the number of contextual objects presented. Therefore, it seems likely that differences in depth of processing would be more likely to be due to the type of processes (i.e. Egocentric-updated or Allocentric) involved rather than the number of contextual details in each condition. These results, hence, suggest that Egocentric-updated processing during episodic encoding facilitates episodic recollection associated with autonomic consciousness.

The results presented here are relevant for current multi-trace type memory models that retain only iconic-egocentric and allocentric representations and which suppose that allocentric encoding is the primary source of representation of episodic memory. Thus, they need to be able to explain this facilitation induced by Egocentric-updated over Allocentric processing. In fact, Burgess, Becker, King, and O’Keefe (2001) and Byrne et al. (2007) have recently proposed that retrieval of episodic information from long-term storage requires the imposition of a particular viewpoint. In this model, the medial temporal lobe uses allocentric representations as a key mechanism for long-term storage while parietal iconic-egocentric representations are used to imagine, manipulate, and re-experience the products of retrieval. The Papez circuit would act as a referential translation system allowing the brain to translate spatial representations according to the direction of view. The original representation in the parietal lobe would be from the subject’s point of view. The translation system transforms this into an allocentric representation for encoding into long-term memory. Upon recall, the translation system rebuilds a subject-centred image from the allocentric memory. Additionally, one could use the translation system to imagine a scene from a different point of view than one experienced during encoding. Viewer-centred representations would then be dynamically generated from long-term memory in the parietal cortex.

In this context, how could we explain the advantage of the egocentric-updated information over the allocentric one? If we consider allocentric representations to be the primary and sufficient source for episodic memory, then egocentric-updated information simply reflects an online process of the reference translation system, with no memory. Then it would be possible to build from allocentric knowledge any given point of view in an egocentric reference coordinate system. However, in that case, the system cannot differentiate illusory translations from an actual re-experiencing of the point of view corresponding to a learned episode. In other words, the system would keep no information to differentiate between imaginary self-projection to a place (i.e., imagination) and real personal memories of that same place (i.e., episodic memory associated with autonomic consciousness).

Now, if we consider that egocentric-updated information is also necessary for episodic memory, then egocentric-updated information would reflect an online process of the referential translation system, with a memory. This memory of egocentric-updated information would be characteristic of episodic memory. In fact, from allocentric knowledge, it would be possible to build any point of view. However, the system would rely on the egocentric-updated information memory to distinguish between re-experiencing (i.e., episodic memory) and imaginary self-projection. Thus, our results would indicate that the enhancement of this memory within the referential translation system would be more effective for episodic retrieval than acute encoding of object-to-object relations within the allocentric coding one.

To conclude, this experiment indicates that egocentric-updated information acquired during encoding yields a better episodic retrieval than encoding which emphasizes object-to-object relations. In the context of Burgess and colleagues’ model, we propose that this advantage could be reflected through the addition of a memory property to the referential translation system.

Acknowledgments

We thank Rebecca Coaslon for her useful comments on the English version of the manuscript. This work was supported by a French grant of the research and national education department.

References


A. Gomez et al. / Acta Psychologica xxx (2009) xxx–xxx