Lexical Production and Cognitive Control in Bilinguals

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Ethical review	Approved WMO
Status	Completed
Health condition type	Other condition
Study type	Observational non invasive

Summary

ID

NL-OMON44342

Source
ToetsingOnline

Brief title
LPCC in Bilinguals

Condition

- Other condition

Synonym
This research utilizes brain imaging techniques with healthy participants only, without any medical applications

Health condition

standard MRI examination without direct medical applications

Research involving
Human

Sponsors and support

Primary sponsor: Universiteit Leiden
Source(s) of monetary or material Support: Partial internal fund provided by cognitive psychology unit of Leiden University

Intervention

Keyword: Bilingualism, Brain, Cognitive Control, fMRI, Lexical production

Outcome measures

Primary outcome

The main endpoint of the study is to delineate the way cognitive control contributes to absence of standard language effect and reversed language effect in bilinguals, when producing L1 and L2 lexical items. We measure the hemodynamic response, or rather indirect consequences of neural activity, in order to have access to detailed patterns of activity in brain when participants perform different sections of the experiment. In doing so, via General Linear Model, voxels with significant activations will be detected. Our particular foci will be in brain regions involved in cognitive control, namely, prefrontal cortex, ACC (Abutalebi et al., 2013; Braver et al., 2001; Bunge et al., 2002; Reverberi et al, 2015), inferior parietal cortex (Braver et al., 2001; Bunge et al., 2002), as well as basal ganglia (Middleton & Strick, 2000). Voxels with significant activations in brain regions involved in cognitive control will be compared a) in pre-switch, in which there is standard language effect (L1 is processed quicker than L2) and in post-switch with new stimuli, in which there is lack of standard language effect (there is no difference between L1 and L2 processing speed) b) in pre-switch, in which there is standard language effect (L1 is processed quicker than L2) and in post-switch

with old stimuli, in which there is reversed language effect (L2 is processed quicker than L1). By making these comparisons we will detect how voxels with significant activations in pre-switch section of the experiment * in which there is standard language effect * change activation in post-switch with new stimuli, in which there is lack of standard language effect, and in post-switch with old stimuli, in which there is reversed language effect. In fact, via seed based approach PPI, the patterns of functional connectivity in three sections of the experimental task (pre-switch in which there is standard language effect, post-switch with old stimuli in which there is reversed language effect, and post-switch with new stimuli in which there is lack of standard language effect) will be detected and compared, in order to understand how cognitive control contributes to absence of standard language effect and reversed language effect in bilinguals.

Secondary outcome

The secondary endpoint of this study is to define any differences in terms of the strength of functional connectivity in brain areas involved in cognitive control, between participants who in post-switch section (with old stimuli) of the experiment reply to the first language faster than the ones who do it more slowly. In fact, participants who reply to the first language more slowly will show the reversed language effect more than the ones who reply to the first language faster. We are interested to know what exact neural mechanism marks one group with more reversed language effect than the other group. By using PPI, we will analyze connectivity in control network - prefrontal cortex, ACC (Abutalebi et al., 2013; Braver et al., 2001; Bunge et al., 2002; Reverberi et

al, 2015), inferior parietal cortex (Braver et al., 2001; Bunge et al., 2002), as well as basal ganglia (Middleton & Strick, 2000) - for task-based fMRI data between these two groups of participants; in addition, we will use multivariate, seed-based approach to assess functional connectivity in three resting state networks that are known to be related to executive control (cognitive control including) (Grady,Luk, Craik, & Bialystok, 2015; Pliatsikas, & Luk, 2016) between these two groups of participants. These analyses will be done to understand how the correlation and strength of functional connectivity in brain areas involved in cognitive control, in both task-based fMRI and resting state fMRI are different between participants who show more reversed language effect than the ones with less degree of this effect.

The three resting state networks that are of interest in this research include:

- the frontoparietal control network (FPC), including dorsolateral and inferior frontal regions and inferior parietal regions (Spreng, Sepulcre, Turner, Stevens & Schacter, 2013),
- the salience network (SLN), including the anterior insula, the dorsal anterior cingulate gyrus and the supramarginal gyri (Seeley et al., 2007),
- the default mode network (DMN), including the posterior cingulate gyrus, the ventromedial prefrontal cortex, the angular gyri and the parahippocampal gyri (Spreng, Mar & Kim, 2009).

Lastly, to understand how the micro-structure of the perisylvian language network is different between participants who in switch section of the experiment have a better performance in switching between first and second language lexical items, which is an indication of superior cognitive

flexibility, than the ones with average performance in the same switch section, via Diffusion Tensor Imaging (DTI), we will focus on three white matter fibre tracts:

- the long segment running dorsally from the frontal lobe (**Broca*s territory*) to temporal structures comprising Wernicke*s area,
- the anterior segment connecting **Broca*s territory* with the inferior parietal cortex (in particular the angular gyrus),
- the posterior segment connecting the inferior parietal lobe to **Wernicke*s territory*.

Per tract, three measurements will be used: fractional anisotropy (FA), mean diffusivity (MD) and volume (in cm3). Via a linear discriminant analysis, we will treat the different tract measurements (FA, MD and volume) as predictors and participants* performance in the switch section of the experiment as the outcome variable, to understand the strength of the contribution of each predictor to the linear function.

Study description

Background summary

In bilinguals, any production in either of the languages leads to the activation of both languages at the same time. The mechanism of language activation in bilinguals is mostly believed to be nonselective, thus, there is a parallel activation of both L1 and L2 lexical representations (Kroll, Bobb, & Wodniecka, 2006; Marian, Spivey, & Hirsch, 2003; Sunderman, & Kroll, 2006). Such a parallel activation of both languages at the same time increases the attentional control in bilinguals, to control the activation of non-target lexical representations (Christoffels, Firk, & Schiller, 2007), which is assumed to occur at the lexical level of word production (Costa, 2005; Finkbeiner, Gollan, & Caramazza, 2006). For a detailed linguistic description

of different stages involved in word production see Bloem and La Heij (2003); Bloem, van den Boogaard, and La Heij (2004); Levelt, Roelofs, and Meyer (1999); Schriefers, Meyer, and Levelt (1990).

In general, those aspects of cognitive control which are involved in selecting and maintaining a response in the face of a conflict and in the presence of some other alternatives are characterized by the involvement of such neural systems as prefrontal, inferior parietal cortex, anterior cingulate cortex (ACC) (Braver, Barch, Gray, Molfese, & Avraham, 2001; Bunge, Hazeltine, Scanlon, Rosen, & Gabrieli, 2002), as well as basal ganglia (Middleton & Strick, 2000). Prefrontal cortex has been recognized to bring about a facilitating processing manner via its top down bias mechanisms when irrelevant candidates compete with those representations which are related to a task (Miller & Cohen, 2001). Prefrontal cortex has strong interconnections with the parietal cortex (Petrides & Pandya, 1984). Such a circuit has been reported to play a role when there is a need to select among some competing responses, with left parietal cortex engaged in activating responses which are possible, and prefrontal cortex involved in selecting a response among competing candidates (Bunge, et al., 2002). In addition to prefrontal cortex, ACC has also been suggested to contribute to response selection. Although prefrontal cortex contributes to response selection when there is a conflict among competing candidates, it is the ACC which formulates the degree of cognitive control (Bush, Luu, & Posner, 2000). In general, the amount of ACC activation depends on the degree of conflict in selecting a response (Carter et al., 1998); in the process of response selection, ACC identifies the conflict among competing cues, then the prefrontal cortex via a signal received from ACC on the existence of a conflict, exerts more control provided by the top down regulatory mechanisms of posterior cortex or the basal ganglia (MacDonald, Cohen, Stenger & Carter 2000). The basal ganglia may also contribute to language planning (Fabbro, Peru, & Skrap, 1997) as well as selecting a suitable lexical item (Wallesch, 1985).

Regarding the neural substrates involved in bilingual lexical production, there has been a debate over the last two decades. Earlier research reported no neural differences underlying L1 and L2 lexical production; thus a common neural system including bilateral network in the frontal, temporal, parietal and occipital cortex along with the cerebellum and limbic system, was mostly emphasized (Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Pu et al., 2001). However, later, literature has witnessed different neural dissociations in L1 and L2 processing. To name a few, as a result of L2 production, one can refer to increased activation in frontal cortex (Vingerhoets et al., 2003), prefrontal cortex (De Bleser et al., 2003), the right insula, the anterior cingulate gyrus, the dorsolateral prefrontal cortex, and the left fusiform gyrus (Hernandez & Meschyan, 2006), the left inferior frontal gyrus (LIFG), bilateral supplementary motor area (SMA), left precentral gyrus, left lingual gyrus, left cuneus, bilateral basal ganglia including the putamen, globus pallidus, and caudate, and bilateral cerebellum (Liua, Hub, Guoa & Peng, 2010). Therefore, it has been argued that in L2 lexical production more neural resources are involved, possibly to overcome L1 interference with L2

production, and to inhibit L1 activation, as L2 production is less automatic (Abutalebi et al., 2008); in contrast, more activation in the right basal ganglia is associated with L1 production (Liua et al., 2010).
In more recent research (Abutalebi et al., 2013; Reverberi et al, 2015) the pre-SMA/ACC, prefrontal cortex and the left caudate, known as language control network, have been reported to be involved in L2 lexical production. It has been mentioned that when producing words in L2 compared with L1 production, the pattern of activation agrees with the language control network, indicating that L2 production requires recruitment of more control processes compared with L1 (Reverberi et al., 2015); however, another network, is assumed to be associated with L1 word production; in fact, Reverberi et al. (2015) reported that L1 word production activates more bilaterally the inferior parietal lobules, the precuneus, the posterior cingulate cortex, and the right lateral prefrontal cortex. It is considered that the activity of the regions involved in the latter network correlate negatively with the activity of the regions involved in L2 word production (Fornito, Harrison, Zalesky, & Simons, 2012).

Study objective

Thus far, what previous literature has dealt with, addresses the neural mechanisms involved in L1 and L2 lexical production separately (e.g. Hernandez & Meschyan, 2006; Liua et al., 2010; Reverberi et al., 2015), irrespective of any explanations on neural mechanisms involved in reversed language effect, and the absence of standard language effect in bilinguals. The present research not only addresses the gap in the related state-of-the-art research, but also investigates the underling mechanisms involved in the aforementioned effects; such investigations contribute to understanding the primary processes involved in bilingual first language attrition and any inspection of the role of cognitive control in those effects provides detailed analysis of the way bilingual brain adopts an adaptive mechanism in producing L1 and L2 lexicons. Therefore, the main incentives of this research revolve around shedding light on the function of neural mechanisms which bring about the reversed language effect, and the absence of standard language effect in bilingual lexical production and the way cognitive control modulates such language behavior.

Study design

This experiment includes a standard structural T1-weighted MRI scan, a Diffusion Tensor Imaging (DTI), a resting state fMRI, and a picture naming task in three sections (pre-switch, switch, post-switch). The experimental design is a 2 (Dutch: English) x 3 (pre-switch: switch: post-switch) factorial design, within and between participants. In this experiment, within subject analysis will look into the contrast in different experimental conditions and between subject analysis concentrates on any differences that could be observed when in pre-switch and post-switch blocks, some participants receive first English block and then Dutch block and some other participants receive this order vice

versa. Dependent measures are participants* reaction times and brain activity in response to different conditions of the experiment. Brain activation during task performance will be measured using standard event-related and blocked design functional MRI. Also, correlations in the fMRI time courses during lexical production will be measured in order to establish the functional connectivity network related to lexical production and cognitive control.
Participants will be instructed about the experimental procedures and will be familiarized with the task that they will do inside the scanner. The first section of the picture naming task, pre-switch, has two conditions (English and Dutch) in block design with 48 task trials and 80 baseline trials in two runs, one run in Dutch and one run in English. Each run consists of three task blocks (with the mean of eight trials in each block) and four baseline blocks (with a mean of ten trials in each block). Task blocks and baseline blocks alternate each other. The duration of pre-switch will be seven minutes.
In switch section, participants will be required to name the stimuli by switching between English and Dutch. Switch section has four conditions (English and Dutch) x (Switch and nonswitch trials) with 96 trials, in which the inter stimulus interval will be jittered. A cue color will hint participants in what language the next image should be named. In switch section, the stimuli will be the ones that are used in pre-switch section. The duration of this section will be six minutes. Based on the behavioral study that has been done in advance by the researcher, switch section is, in fact, where the facilitatory function over bilinguals* second language, an inhibitory function over their first language along with reversed language effect, are expected to occur.
Post-switch has four conditions (English and Dutch) x (new and old stimuli) with 96 task trials and 160 baseline trials in four runs, two runs in Dutch and two runs in English. Each run consists of three task blocks (with the mean of eight trials in each block) and four baseline blocks (with a mean of ten trials in each block). Task blocks and baseline blocks alternate each other. This section will take fourteen minutes. Compared with pre-switch section, post-switch section has two runs more. Post-switch section will include both, stimuli used in pre-switch and new stimuli. Based on the behavioral study that has been done in advance by the researcher, post-switch is where reversed language effect, and the absence of standard language effect are expected to be observed.

Study burden and risks

Participating in an fMRI and DTI study has not been associated to any known risks. These non-invasive techniques involve no catheterizations or introduction of exogenous tracers. Numerous children and adults have undergone magnetic resonance studies without apparent harmful consequences. Some people become claustrophobic while inside the magnet and in these cases the study will be terminated immediately at the subject's request. The only absolute contraindications to MRI studies are the presence of intracranial or intraocular metal, or a pacemaker. Relative contraindications include pregnancy

and claustrophobia. Participants who may be pregnant, who may have metallic foreign bodies in the eyes or head, or who have cardiac pacemakers will be excluded because of potential contraindications of MRI in such subjects.
Although there is no direct benefit to the participants from this proposed research, there are greater benefits to society from the potential knowledge gained from this study.
There is no direct benefit to the participants from this research; however, this research by addressing the gap in the related state-of-the-art research, provides insights on the function of neural mechanisms involved in bilingual lexical production, and cognitive control; especially given that the importance of the benefits gained from this research far outweighs the minimal risks involved.
In this study, participants will be protected against any MRI procedural risks via a thorough pre-screening process. Information obtained from the study will be strictly confidential, except as required by law, and will be made available to the subject and his/her physician in response to a specific request from the subject. There will be no personal identification of subjects in scientific communications. Data will be stored in a confidential manner both through the use of a coding system (a code will be assigned to the data from a given subject instead of the subject*s name) and through the security of the files and computer systems.
All standard anatomical images (i.e. localizer images) are routinely reviewed by a neuroradiologist. fMRI studies are not given a clinical interpretation. In the event that a significant abnormality is detected, a recommendation to seek further medical consultation will be made. However, it is stressed that the MRI evaluation performed for these studies does not represent a complete clinical MRI evaluation, and it is not being performed for clinical diagnostic purposes.

Contacts

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Trial sites

Listed location countries

Netherlands

Eligibility criteria

Age
Adults (18-64 years)
Elderly (65 years and older)

Inclusion criteria

Participants will be healthy, volunteer, right-handed Dutch-English bilinguals, without any report and history of neurological or psychiatric problems and no counter-indications to MRI. Their age will not be more than thirty.

Exclusion criteria

Left-handed volunteers, balanced bilinguals, the ones who are more than 30 years old, and have any report and history of neurological or psychiatric problems, will be excluded from this study. Potential participants will be pre-screened for contraindications for fMRI, which include metal implants, heart arrhythmia, claustrophobia, and possible pregnancy (in females). The ones with the positive results in pre-screen section will be excluded.

Study design

Design

Study type: Observational non invasive

Masking:	Open (masking not used)
Control:	Uncontrolled
Primary purpose:	Other

Recruitment

NL

Recruitment status:	Completed
Start date (anticipated):	03-01-2018
Enrollment:	60
Type:	Actual

Ethics review

Approved WMO Date:	17-11-2017
Application type:	First submission
Review commission:	METC Leiden-Den Haag-Delft (Leiden)
Approved WMO Date:	22-01-2018
Application type:	Amendment
Review commission:	METC Leiden-Den Haag-Delft (Leiden)

Study registrations

Followed up by the following (possibly more current) registration

No registrations found.

Other (possibly less up-to-date) registrations in this register

ID: 27895
Source: Nationaal Trial Register
Title:

In other registers

Register	ID
CCMO	NL61816.058.17
OMON	NL-OMON27895