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Proper and Common Names in the Semantic System

Rutvik H. Desai[a,b], **Usha Tadimeti**[a], **Nicholas Riccardi**[a]

[a]Department of Psychology, University of South Carolina, Columbia, SC 29201, USA

[b]Institute for Mind and Brain, University of South Carolina, Columbia, SC 29201, USA

Abstract

Proper names are an important part of language and communication. They are thought to have a special status due to their neuropsychological and psycholinguistic profile. To what extent proper names rely on the same semantic system as common names is not clear. In an fMRI study, we presented the same group of participants with both proper and common names in order to compare associated activations. Both person and place names, as well as personally familiar and famous names were used, and compared with words representing concrete and abstract concepts. A whole-brain analysis was followed by a detailed analysis of subdivisions of four regions of interest known to play a central role in the semantic system: angular gyrus, anterior temporal lobe, posterior cingulate complex, and medial temporal lobe. We found that most subdivisions within these regions bilaterally were activated by both proper names and common names. The bilateral perirhinal and right entorhinal cortex showed a response specific to proper names, suggesting an item-specific role in retrieving person and place related information. While activation to person and place names overlapped greatly, place names were differentiated by activating areas associated with spatial memory and navigation. Person names showed greater right hemisphere involvement compared to places, suggesting a wider range of associations. Personally familiar names showed stronger activation bilaterally compared to famous names, indicating representations that are enhanced by autobiographic and episodic details. Both proper and common names are processed in the wider semantic system that contains associative, episodic, and spatial components.

Keywords

semantics; proper names; people; places; autobiographical memory; fMRI

Introduction

Proper names play a central role in day-to-day language, and are critical for social functioning. Linguistic, neuropsychological, and philosophical theories often argue that proper names have a special status in language (Kljajevic & Erramuzpe, 2018). While common nouns and verbs refer to categories of objects and events/states respectively, proper nouns refer to unique entities. It is suggested that they are directly referential expressions, and do not name things like common nouns do (Semenza & Zettin, 1989). In other words, it is argued that proper nouns lack meaning in the sense in which common

Correspondence: Rutvik H. Desai, rutvik@sc.edu, Phone: 803-777-5662.

nouns have meaning. Linguistically, they often follow different morpho-syntactic rules (Van Langendonck, 2007). They are more susceptible to forgetting relative to common nouns, controlling for phonological form and frequency (Cohen & Burke, 1993). Cases of patients with proper name anomia (Fukatsu et al., 1999; Martins & Farrajota, 2007; Semenza, 1997; Semenza & Zettin, 1988, 1989), with relatively spared common naming, seem to corroborate this special status of proper names. With this backdrop, one might expect proper names to have clearly distinct neuroanatomical correlates when compared to common names. The search for the neural basis of proper names, however, has revealed areas that are consistently associated with the semantic system and common names. This is surprising given that proper names are expected to be mostly or entirely separate from 'common' semantic memory in the above view.

Within the semantic system, angular gyrus (AG) is a central region suggested to be a multimodal or integrative hub (Binder & Desai, 2011; Bonner et al., 2013; Fernandino et al., 2016; Seghier, 2013) that is activated for all types of common nouns, verbs, and sentence stimuli (Binder et al., 2009). AG is found to be activated for proper names as well (Gorno-Tempini et al., 1998; Sugiura et al., 2006; Sugiura et al., 2009). Cases of proper name deficits are also reported with damage to AG (Martins & Farrajota, 2007).

Another region associated with proper names is the anterior temporal lobe (ATL), with many studies suggesting that it has a special role in proper name and person attribute retrieval (Abel et al., 2015; Damasio et al., 1996; Grabowski et al., 2001; Mehta et al., 2015; O'Rourke & de Diego Balaguer, 2020; Pisoni et al., 2020; Tranel, 2009; Wang et al., 2017). For example, Pisoni et al. (2020) used famous person recognition (face and voice) and naming tasks in a transcranial direct current stimulation (tDCS) study. They found that the right ATL supports famous person recognition from visual inputs and access to personal semantics. The left ATL was crucial for proper naming. This is consistent with a review of patient studies by Gainotti (2007), which suggested distinct roles of the left and right ATL. Damage to the left ATL was associated with proper name retrieval deficits, while that to the right ATL resulted in a loss of familiarity and loss of specific information about a person. In the dual-process model proposed by O'Rourke and de Diego Balaguer (2020), the bilateral temporal pole is selectively involved in proper name retrieval through its connection to orbito-medial prefrontal cortex via uncinate fasciculus. Anterior temporal areas just posterior to the temporal pole participate retrieval of information relevant to specific common nouns and definite noun phrases. These regions are connected to AG through inferior longitudinal fasciculus, which is proposed to have a role in both common and proper noun retrieval through item-item and item-context associate memories. Semenza (2011) suggests that the involvement of left temporal pole in proper name processing may be mediated by its connection with ventromedial prefrontal cortex, which is important for social cognition and interaction. With regard to common names, bilateral ATL is also a putative semantic hub where all types of concepts are integrated (Ralph et al., 2017; Rice et al., 2015).

Two other regions with semantic-hub-like characteristics are the posterior cingulate complex[1] (PCC) and the medial temporal lobe (MTL) (Fernandino 2016). Fernandino et al. (2016) examined activation in response to concepts that varied in saliency of five sensory-motor features. The found that PCC and parahippocampal cortex were among the areas that were modulated any of the features, suggesting that they are part of a general semantic network. These two regions are also regions associated with proper names in neuroimaging studies (Gorno-Tempini et al., 1998; Sugiura et al., 2006; Sugiura et al., 2009; Wang et al., 2017). In the dual-process model (O'Rourke & de Diego Balaguer, 2020), anterior MTL regions, including perirhinal cortex, supports the encoding and retrieval of unitized memory. Unitization is a process by which two or more separate features or items are combined to form a single mnemonic unit. Unitized memories especially support familiarity judgments. On the other hand, posterior MTL regions including hippocampus and parahippocampal cortex, along with PCC and AG, support non-unitized item-context and item-item encoding.

One possibility is that proper and common names appear to rely on the same regions only under a broad definition of "region." All of these hub areas have multiple subdivisions that have distinct connectivity and potentially different functional roles. One subdivision of angular gyrus, for example, might specialize in common names while the other in proper names. This may appear to be the same area only when using a general anatomical label and comparing different studies.

Another dimension in processing of proper names is the distinction between people and places. Some theories (Morton et al., 2021) suggest that an anterior-temporal network involving the ATL, inferior frontal/orbitofrontal cortex, and amygdala, due to its role in processing of social stimuli, is associated with names of people. A posterior-medial network, consisting of AG, PCC, and parahippocampal cortex represents situation models and hence representation of places (Dijk & Kintsch, 1983; Ferstl & von Cramon, 2007; Henderson et al., 2011; Rugg & King, 2017; Thakral, Benoit, et al., 2017; Thakral, Madore, et al., 2017). Both networks are functionally and anatomically connected to the hippocampus (Kahn et al., 2008), which may represent domain-general conceptual content.

An additional possibility is that some proper names are special due to their association with rich autobiographical information. Three semantic hubs discussed above — AG, PCC, and MTL — are also part of the autobiographical memory network (Cabeza & St Jacques, 2007; Rissman et al., 2016; Svoboda et al., 2006). Areas within this network may respond specifically to personally familiar entities, reflecting autobiographical or episodic memory-related processes.

In this study, we investigated whether distinct hubs, or distinct subdivisions within hubs, show a preferential response for (1) proper vs. common names, (2) people vs. places, and (3) personally familiar vs. famous people and places. We presented both proper and common names to the same group of participants, avoiding the issue of anatomical variability between different groups of participants and the resulting loss of spatial precision. Proper names were presented in a 3 x 2 design, with personally familiar, famous, and unfamiliar names crossed with people and places. We are especially interested in the response of the four hubs discussed above: AG, ATL, PCC, and MTL. Using the Human Connectome

[1]We use the term 'posterior cingulate complex' as a stand-in for an area encompasing posterior cingulate, retrosplenial cortex, and precuneus.

Project (HCP) atlas (Glasser et al., 2016), we identified five subdivisions within each of these four regions, which were probed for their response to proper and common names.

Materials and Methods

Participants

Twenty-one healthy right-handed native English speakers (10 females; average age 25, range 18 to 34 years) with no history of neurological illness participated in this study. A written informed consent was obtained from them prior to the experiment in accordance with the protocol sanctioned from Medical College of Wisconsin Institutional Review Board. They were compensated for their participation.

Stimuli

The stimulus set consisted of 240 names, divided into 40 names each of famous persons (e.g., Barack Obama, Nelson Mandela), famous places (e.g., Hollywood, Statue of Liberty), personally familiar persons, personally familiar places, unfamiliar persons, and unfamiliar places. The participants provided a list of personally familiar people and places a few days before the experiment. They were instructed to provide names of people and places with a range of familiarity. The unfamiliar people names were collected from a telephone directory, and names of obscure real places were collected as unfamiliar places. The familiarity or unfamiliarity of the items was verified using ratings after the experiment (see Experimental Paradigm below). The mean length of all conditions was between 11 and 14 letters. The list of famous and unfamiliar items used in this experiment is provided in the Supplementary Table S1.

To compare activations to proper names to common names, 100 words (50 concrete and 50 abstract words, matched in frequency and length) and 100 pronounceable pseudowords were used (Supplementary Table S2).

Experimental Paradigm

The stimuli were presented visually at the center of the screen in white Arial font on a black background. All words in the name were presented simultaneously. Each stimulus was presented for one second. The participants were instructed to decide whether they were familiar with the person or place and respond “as quickly as possible without making mistakes,” by pressing one of the two keys on the button box with index or middle finger. The finger and hand used for a positive response were counterbalanced across subjects. Prior to entering the scanner, subjects were trained on the task outside the scanner using stimuli not used in the main experiment.

For words, the subjects were asked to indicate whether the displayed string was a real word or not, in the same manner.

The stimuli were presented in a pseudo-random order in a jittered event-related design. The interval varied between 2.5 and 12 seconds. The experiment was divided into 4 runs, with person and place names presented in alternating runs. Each run contained 20 items from each person or place condition. A fixation cross (“+”) was displayed during the interstimulus interval. The order of the stimuli was randomized using the *Optseq* program (Burock et al., 1998). E-Prime software was used for presenting the stimuli and collecting the response times and accuracies of the subjects during the task.

After the scanning session, the subjects were asked to rate each of the names shown in the scanner on “amount of knowledge” (KN) and “valence” (VL). For the KN rating, subjects were asked to rate the amount of information or knowledge they had about a person or place on a scale of 0 to 10. Zero corresponded to a completely unfamiliar person/place, while 10 corresponded to very high degree of knowledge that typically comes with years of association (e.g., with a spouse or a home). For the VL rating, the emotional valence was rated on a scale of +10 (strong positive response) to −10 (strong negative response).

Image Acquisition

MR images were acquired with a 3.0 Tesla long bore scanner (GE Medical Systems, Milwaukee, WI). Structural T1 weighted images were collected using SPGR sequence (TR=8.2 ms TE=3.2 ms, flip angle=12, FOV= 240 mm, 256 x 224 matrix, slice thickness = 1mm). Functional data consisted of gradient echo planar images (EPI) (TR= 2500 ms, TE=20 ms, flip angle=80, FOV=192 mm, 96 x 96 matrix, slice thickness=2 mm, functional voxel size=1.5 x 1.5 x 2 mm^3, anatomical voxel size=.938 x .938 x 1 mm^3). 34 oblique slices covering the temporal lobe, inferior frontal and supramarginal gyri were collected. Oblique acquisition, combined with low TE and small voxel size were chosen to minimize signal loss in the anterior temporal lobes. The TSNR values for all regions of interest (see fMRI Data Analysis below) were > 40, with most being > 100 (see Supplementary Table S3).

fMRI Data Analysis

The AFNI software package (Cox, 1996) was used for image analysis. Within-subject analysis involved slice timing correction, spatial co-registration (Cox & Jesmanowicz, 1999) and registration of functional images to the anatomy (Saad et al., 2009). Voxel-wise multiple linear regression was performed using reference functions representing each condition convolved with a standard hemodynamic response function. If the participant rated a name expected to be familiar as unfamiliar, it was coded as unfamiliar, and vice versa. Reference functions representing the six motion parameters, and the signal from CSF, were included as covariates of no interest. General linear tests were conducted to obtain contrasts between conditions of interest. The individual statistical maps and the anatomical scans were projected into standard stereotaxic space (Talairach & Tournoux, 1988) and smoothed with a Gaussian filter of 6-mm full-width-half-maximum.

First, exploratory whole-brain analyses were conducted, followed by ROI analyses in the four bilateral regions of interest (AG, ATL, PCC, MTL). For group level whole-brain analysis, a t-test was carried out to compare different stimulus conditions. The group maps were thresholded at voxelwise $p < 0.01$ and corrected for multiple comparisons to achieve a mapwise corrected 2-tailed $p < 0.05$ using AFNI program 3dClustSim. Only the voxels within a mask that included smoothed gray matter, but excluded areas outside the brain, deep white matter areas, and ventricles, were analyzed.

We use the term “familiar” to describe the combination of personally familiar and famous items. Three contrasts maps were computed for proper names: familiar vs. unfamiliar items, people vs. places, and personally familiar vs. famous items. For common names, words vs. pseudowords contrast was computed. Note that our main goal was to examine areas activated by known proper names (relative to their controls, namely unknown names) and those activated by words (relative their controls, namely pseudowords) to ask which, if any, areas might be specialized for proper names especially in the putative semantic hub regions. Hence, we emphasize the ROI analyses described below that contrast proper and common names *with their respective controls* rather than to each other. We do not emphasize direct comparisons between proper and common names to see which regions may be activated more for proper relative common names or vice versa. Proper and common names differ in a number of ways, including taxonomic and associative semantic features, orthographic properties, and phonological properties. General differences between them were not the primary focus of this investigation.

For the ROI analyses, regions from the HCP atlas included in AFNI were selected. Four ROIs were defined bilaterally to include the following five subdivisions: AG - PGi, PGs, PFm, TPOJ2, TPOJ3; ATL – TGd, TEa, TGv, STGa, STSa; PCC – 23, 31, 7m, PCV, RSC; MTL – H, PHA, PeEc, PreS, EC. Of those subdivisions, the following were created by combining smaller, anatomically adjacent atlas regions that displayed similar response profiles into a single subdivision: TEa – TE1a and TE2a; STSa – STSva and STSda; 23 – v23ab and d23ab; 31 – 31pd and 31a; PHA – PHA1, PHA2, PHA3. The ATL ROI was truncated using a plane perpendicular to the axis of the temporal lobe, in order to include approximately 1/3 of the anterior section of the temporal lobe. Each region was probed for activation for both proper and common names, relative to their control conditions. Person and place names were compared with respective unfamiliar names, while words were contrasted with pseudowords. Note that comparison with a rest or fixation baseline would not be as informative or appropriate for our purposes. Rest is an active semantic condition where concepts related to people, places, plans, episodes are likely to be active (Binder & Desai, 2011; McKiernan et al., 2006; McKiernan et al., 2003). Control conditions used here (names of unfamiliar people and places, and pseudowords) control for orthographic and phonological demands, attentional demands, as well as the button-press action. Bonferroni correction was applied to each bilateral ROI to control for multiple comparisons.

Each ROI was also examined for correlation with participant-specific KN and absolute value of VL ratings, to test whether the response of any subdivision is driven by the (rated) amount of knowledge associated with a proper name, or by the hedonic valence associated with the names.

Results

The mean reaction times (s.d.) in milliseconds for each condition were as follows. Personally Familiar People: 738 (88); Famous People: 823 (114); Unfamiliar People 932 (176); Personally Familiar Places 743 (110); Famous Places 833 (142); Unfamiliar Places 912 (187). For both places and people, a pattern of personally familiar < famous < unknown was found in pairwise t-tests ($p < 0.05$). No differences were observed between people and places (p > 0.05). The correlation between KN and VL ratings was 0.68 ($p < 0.001$). For words, the RT was 680 (75) and for nonwords it was 802 (93).

Whole-brain Analyses

The exploratory activation maps are displayed on an inflated brain surface (Fig. 1), and cluster and peak information is shown in Tables 1-4.

Familiar names > Unfamiliar names: The comparison of familiar names (people and places) relative to unfamiliar items revealed a large bilateral network (Fig. 1a, Table 1), with a left > right pattern. This included bilateral AG, supramarginal gyrus (SMG), posterior, middle, and anterior middle temporal gyrus (MTG), inferior temporal gyrus (ITG), anterior superior temporal gyrus (STG) and sulcus (STS), and lateral orbitofrontal cortex (OFC). Bilateral hippocampus and surrounding regions, including parahippocampal gyrus (PHG), amygdala, enthorhinal and perirhinal cortex, fusiform gyrus (FG), caudate and thalamus were activated. A large cluster in the bilateral PCC and a smaller cluster in anterior cingulate was also observed.

Familiar people > Familiar places: This contrast activated a right-dominant subset of network activated above, and included the right AG, SMG, posterior and anterior MTG, and STG (Fig. 1b, Table 2). The left mid MTG was also activated, along with bilateral dorsal PCC.

Familiar places > Familiar people: Compared to people, places activated bilateral ventral precuneus, extending into the isthmus of the cingulate gyrus (Fig. 1b, Table 2). Bilateral PHG and FG were also activated by places.

Personally familiar > Famous names: This contrast activated regions that were largely similar to the familiar > unfamiliar comparison, but the intensity and extent of activations were smaller, and the activations were somewhat right lateralized (Fig. 1c, Table 3). Bilateral AG, SMG, posterior and mid MTG, precuneus, posterior cingulate, PHG, ethorhinal cortex, and anterior cingulate were activated. Activation as also found in the right IPS, OFC, and amygdala. No activation was found in the reverse (famous > personally familiar) contrast.

Familiarity (personally familiar, famous) x Type (people, places) interaction activated bilateral posterior cingulate/precuneus complex, and the right AG (Supplementary Figure S1, Supplementary Table S4).

Words > Pseudowords and Overlap: This contrast activated a widespread network of areas very similar to the one for Familiar > Unfamiliar names (Fig. 1d, Table 4). An overlap map of Words > Pseudoword contrast to Familiar People > Unfamiliar people contrast is shown in Supplementary Figure S2.

ROI Analyses

Angular Gyrus: Responses of each subregion in each hemisphere are shown in Fig 2. Most subregions showed significant response to proper names, including personal and famous names, as well as people and places. A general pattern of stronger response for personal compared to famous entities, and for people relative to places, was observed. The right TPOJ2 (which can be considered mostly part of the posterior middle temporal gyrus) was an exception, with a nonsignificant response to places and famous entities. PGi was the only region to show a correlation with KN rating (greater response with greater rated knowledge about specific people and places).

For common names, virtually all subregions in the LH and RH showed a strong response to words, including both concrete and abstract words, with the right PFm showing a trending response.

Anterior Temporal Lobe: Most subdivisions within the bilateral ATL showed a response to proper names in all categories, with some exceptions (Fig. 3). The right STGa responded significantly only to famous people, with a trending response to famous entities and people. Secondly, neither left nor right TGv responded to any individual category. Bilaterally, area TGv showed a weaker response to all categories. The right STSa, TEa, and TGd showed a positive correlation to the KN regressor, with the left STSa and TEa showing trends. The right TEa and left STSa showed trends for VL.

For common names, most subdivisions again showed a response to words. Like proper names, bilateral TGv showed a weaker, trending response to words (except a significant response to abstract words in the right TGv). Power in this region can be reduced due to signal loss in this ventral temporal location. The right STGa was also nonsignificant, with a trend only for abstract words.

Posterior Cingulate Complex: All regions responded to most or all proper names. Only the right RSC did not respond to famous entities. The right PCV responded to people but not to places. Famous places showed the lowest response in all subdivisions, with the weakest response in the RH.

For common nouns, all subdivisions in the left PCC responded to words and to concrete and abstract categories individually, with the exception of right RSC, which did not respond words. In the right PCC, all subdivisions responded to words overall, but the response to abstract words was only trending. The left area 31 ROI responded positively to both KN and VL regressors, with the left 7m and PCV showing trends in the same direction.

Medial Temporal Lobe: All subdivisions in the MTL showed a response to personal items. With the exception of the left PeEC and bilateral PreS, they also responded to famous items. In the people/places dimension, response to both people and places was seen in most subdivisions. Bilaterally, PreS did not respond to people but did show a response to places. The right PeEC showed the reverse pattern, responding to people but not to places. None of the subdivisions exhibited a correlation to KN or VL ratings, but right hippocampus showed a trend for a positive correlation with VL.

For common names, most subdivisions responded to concrete words, but none to abstract words. The right EC and left PeEC failed to respond to any word category, with the right PeCE showing only a trend.

Discussion

We examined BOLD responses to proper and common names, focusing on four regions that are thought to play a central role in the semantic system. Overall, significant overlap was found between responses to proper and common names. This allows us to address three interrelated questions posed in the Introduction.

Proper vs. Common Names: Are Proper Names Special?

While it is often suggested that proper names have a special status psychologically, linguistically, and neurally, all four regions, and almost all of their subdivisions, responded to both proper and common names. The strong overlap between proper and common names suggests that proper names are concepts that are processed in the semantic system along with common names, at least in the context of a recognition task. Even though each proper name represents a unique entity, that entity consists of many features that individually overlap with features of other entities. Activation of semantic hubs, such as AG and PCC may reflect activation and integration of these features. Thus, while a proper name refers to a concept that is in a category with a single exemplar, that exemplar has rich semantic content, which is reflected in activation of the semantic system.

The left AG is among the most commonly activated semantic hubs in response to words and sentences (Binder et al., 2009), and all three of its subdivisions, PFm, PGs, and PGi were activated by proper names. Both personal and famous names, and people and places, activated all three regions bilaterally, with the exception of PFm, which responded to people. They were also activated by words relative to pseudowords, with the pattern of stronger activation for concrete words in the RH. The right PFm was activated in a meta-analysis of Theory of Mind studies (Desai et al., 2018; Schurz et al., 2017), and here its activation could reflect related associations with familiar people. Similarly, in ATL and PCC, most subdivisions showed a response to both proper names and at least one category of common names.

In the MTL, the right entorhinal and perirhinal cortex (approximately areas Ec and PeEC), and the right RSC within PCC, activated for proper names, but not for words. Functions of human entorhinal and perirhinal cortices are subjects of active investigation. According to the Binding of Item and Context (BIC) model (Ranganath, 2010), perirhinal cortex supports retrieval and encoding of item specific information. Our results suggest that these regions play a specific role in person and place name information retrieval. These regions can be interpreted as serving as pointers to proper name specific information stored in the general semantic system. Note that this activation is specific only in relation to a lexical decision task on common names, which has relatively low semantic demands. These regions can be activated for general semantics as well in more explicit tasks, especially for tasks involving picture stimuli. For example, Wright et al. (2015) showed that damage to perirhinal cortex bilaterally results in impaired performance in picture naming and word-picture matching tasks for common objects/names, especially for items that are semantically confusable. In an fMRI study, similar effects were shown in healthy participants for picture similarity in bilateral perirhinal cortex by Clarke and Tyler (2014). Liuzzi et al. (2019) found sensitivity in the left (but not right) perirhinal cortex for an explicit semantic task on words. The entorhinal cortex also has a role in visual processing. Stimulation of the right entorhinal cortex improved specificity of memory of pictures of (unknown) people (Titiz et al., 2017). The primate entorhinal cortex contains spatial maps (Killian et al., 2012) that may be used for encoding spatial representation of visual scenes and objects.

It is noteworthy that the right Ec and PeEC were activated here when proper names were presented exclusively in verbal format, albeit visually. This result would appear to be inconsistent with the proposals of the left/verbal and right/nonverbal distinction made in several studies (Gainotti, 2020; Pisoni et al., 2020). It is, however, consistent with behavioral studies such as Ohnesorge and Van Lanker (2001) as well as Van Lanker and Ohnesorge (2002). Using written word/nonword and famous/unknown name stimuli in a divided visual field paradigm, they showed that both hemispheres can process famous proper names. A possible reconciliation is that the right anterior temporal activations here represent implicit or spreading activation to visual features of proper names such as faces. At least, the current results demonstrate that a nonverbal or pictorial input is not necessary for the activation of right anterior temporal areas.

Whole-brain analyses indicated orbitofrontal areas activated by person names, with much less activation by words. This can be explained by processing of emotional valence associated with people. Orbitofrontal areas are also activated when more emotional words or sentences with common names are processed (Desai et al., 2018), and is thus not unique to proper names. By and large, proper names do not appear to have distinct dedicated neuroanatomical bases, at least when considering macro level areas at the scale of several millimeters or larger. We suggest that the right entorhinal and perirhinal cortex have a role in linking proper names to semantic features, and they also play a similar role for other specific visual stimuli.

If both proper and common names have largely similar neuroanatomical bases, how can proper-name-specific anomias be explained? While proper names have features that overlap with those of other concepts, the specific combination of features is unique for each proper name. Proper names may be more fragile because the specific combination is strengthened only when that specific concept is retrieved, but not when similar concepts are retrieved. This is similar to deficits in processing common names seen in patients with semantic dementia (Patterson et al., 2007). Even in early stages of semantic dementia, patients exhibit a loss of features that are unique or rare. For example, the knowledge that camels have humps, or penguins are birds that cannot fly, is lost but not the knowledge that camels have four legs or that penguins have beaks. Unique features are more fragile because they are reinforced in relatively few cases, and do not benefit from “coherent covariation” with other features (McClelland & Rogers, 2003). We propose that proper names are fragile for the same reason: their unique distributional pattern of feature activation does not benefit from activation of other similar concepts. Note that this is a qualitative difference in the nature of mapping between the name and semantic features, which is not necessarily reflected in behavioral indices such as response time. Even if response time between a given set of proper and common names is equal, a deficit in proper naming can occur due to the nature of mapping between the name and features. Semenza (2009) has proposed a similar view, that the link between proper names and their reference is particularly fragile, because it does not map onto general semantic characteristics. When damage is restricted to the temporal pole in early semantic dementia, loss of unique features of common name concepts is also seen, as mentioned above. Our view is also consistent with the idea that the temporal pole is especially important for proper names due to the importance of social cognition for proper names, especially person names (O'Rourke & de Diego Balaguer, 2020; Semenza, 2011). Connections of the temporal pole to ventromedial prefrontal cortex may make it suitable for accessing important social and emotional features. We only suggest that the difference between proper and common names is not absolute, but is graded in nature. The temporal pole is also used for common nouns, but social and emotional features of common nouns are often less salient than they are for proper nouns. In this view, the temporal pole does not represent a “distinct pathway” but a somewhat heavier weighting of a branch of a common pathway. This disagrees with one aspect of the dual-process view (O'Rourke & de Diego Balaguer, 2020) , where the temporal pole is thought to be dedicated to proper names, while anterior temporal areas posterior to the pole specialize in common names.

An important caveat to the results here is that we only used a name recognition task. Many of the studies discussed above rely on a name production task, most commonly from famous faces. Deficits in patients are more readily seen in production tasks. Thus, the results from studies using recognition vs. production tasks are not necessarily comparable. Production is a more demanding task, in that it requires retrieval of the name and its phonological form, syllabification as well as speech-motor planning and output. We expect that regions activated for recognition will also be activated for the more demanding task of production, with production activating additional areas. Hence, we suggest that findings relating to the overlap between proper and common names, in the areas considered here, are likely to be valid even if a production task were used. Note that our task for the common names also involves only recognition. The two tasks are comparable in the sense that one task involves distinguishing a known proper name from and unknown one, and the other requires distinguishing a known common name from an unknown one. A future direction is to compare proper and common names in production tasks. If the suggestion above is correct, then overlap in these hub regions should be observed even in the two production tasks, but this awaits empirical verification.

With regard to covariates measuring amount of knowledge and valence associated with proper names, only the left PGi, left area 31, and right ATL regions showed a significant correlation. This is consistent with the proposed role of AG in processing thematic relations, as suggested by numerous studies (for a review, see Mirman et al., 2017). The results suggest that within AG, area PGi is especially sensitive to the size of associative network. Area 31 in PCC, and the right ATL also showed a similar correlation. The right ATL response in STSa, TEa, and TGd is consistent with the findings of Gainotti (2007). Damage to the right ATL resulted in loss of specific information about people and a loss of familiarity. The right ATL is also associated with affect and social processing (Olson et al., 2013). These subdivisions may have a role in representing semantic associations that are social in nature. Furthermore, size of the semantic network and affective response are correlated, as more familiar entities (such as immediate family members or one’s home) also tend to have stronger affective associations. The KN rating may be a stand-in for overall affective and social associations with proper names, a possibility that is consistent with the affective account of the right ATL response.

People vs. Places

With a few exceptions, most of the subdivisions in the four ROIs that showed a response to person names also responded to place names. Whole-brain analyses indicated an especially stronger activation in the RH for people, especially in the right AG and the right temporal lobe. Area PFm in the right AG, area PCV in the right PCC, TEa and TGd in right ATL, and PeEC in the right MTL were the subdivisions showing a response for person names but not place names. This right lateralized pattern may be explained in terms the Coarse Coding Hypothesis (Jung-Beeman, 2005; Jung-Beeman & Chiarello, 1998). In this view, the RH arouses and sustains a more diffuse network of remote associations and secondary meanings of words, while the LH quickly focuses on strong associates and a narrow range of dominant interpretations. Person names may have more wide-ranging and remote associations than place names, leading to greater activation of the RH. Additionally, the right TEa and TGd are specially associated with retrieving person-specific attributes as discussed above, and the right AG has a role in Theory of Mind (Schurz et al., 2017). Activation of ATL for person names or faces is often interpreted as that of person identity nodes in the model of Bruce and Young (Bruce & Young, 1986; Perrodin et al., 2015). Here, we show that the left ATL is activated for place names as well as person names, suggesting that person-specific nodes may be located specifically in the right ATL in TEa and TGd.

Place names activated parahippocampal and retrosplenial cortex over person names in the whole-brain analysis. In the ROI analysis, only the bilateral PreS in MTL showed a pattern with significant response to places but not to person names. Bilateral PHA responded to both people and places, but was the only other region to show a greater response magnitude to places over people. These results support a more spatial nature of representation of place concepts even for an implicit task that used only names. In the MTL, Ec, H, PHA, and PreS regions also showed response to concrete words but not to abstract words, supporting a more visuo-spatial format for both proper and common names.

These results only partially support a dual-network view (Morton et al., 2021), where an anterior-temporal network involving the ATL, inferior frontal/orbitofrontal cortex, and amygdala, is associated with names of people. A posterior-medial network, consisting of AG, PCC, and parahippocampal cortex represents situation models and hence is associated with representation of places. While parts of the parahippocampal cortex and PCC do support place name processing, other parts of PCC, as well as AG, process both people and place names. Additionally, place names are also processed in the ATL. We note that Morton et al. (2021) identified anterior and posterior areas for people and places respectively using Representational Similarity Analysis with images as stimuli, while we used direct univariate response to personal and place names. The regions reported here may not exhibit a fine-grained similarity between images of people and places, but they nonetheless respond to meaningful or known names relative to unfamiliar names.

The results here are similar to those reported by Silson et al. (2019). They found that a dorsal division in PCC selectively responds to people names, and a ventral division to place names. This is identical to our result in the whole brain analysis, where the same ventral and dorsal responses were found bilaterally in a direct contrast between people and place names (Fig. 1b). This may appear contradictor to the ROI analysis, where all divisions within PCC except PCV showed a response to both people and to places, relative to the control of respective unknown names. Thus, in terms of HCP regions, while the right PCV is selective to personal names, the ventral divisions such as RSC and area 23 are not selective to place names, but only show a relative difference in magnitude. However, the ROIs defined by the HCP resting state parcellation do not precisely map onto regions that are potentially selective for people and places. Hence, the whole-brain results are more informative with respect to specialization for people vs. place names in this instance. A noteworthy difference between Silson et al. (2019) and the current study is that they used a baseline of rest, which does not control for general cognitive processes such as phonological and orthographic processing, and executive processes such as attention involved in reading names, while our use of unknown names does. Woolnough et al. (2020) provide another relevant finding for PPC at a higher spatial resolution in an intracranial recording study, although they used a face and scene naming task rather than proper name recognition task. They found that PCC responds to both specific faces and scenes, but some electrodes are selective to either faces or scenes, while others respond to both faces and scenes.

Personally Familiar vs. Famous Names

A final dimension of comparison is between personally familiar and famous names, with results showing similarity to prior findings (Sugiura et al., 2006; Sugiura et al., 2009). Personal semantics contain components of both semantic and episodic memories (Renoult et al., 2012). While both personal and famous names are expected to activate semantic and episodic information, personally known names have more strongly associated autobiographical information. Clearly, our task is not a typical autobiographical memory task that involves explicit recall or presentation of specific experiences of the participant. Nonetheless, one can expect implicit activation of traces of autobiographical memories when processing personally familiar names of people and places. We found that all four ROIs were more strongly activated bilaterally by personally familiar compared to famous entities. This is consistent with involvement of AG, PCC, and MTL in the autobiographical memory network (Svoboda et al., 2006). In a meta-analysis, Spreng et al. (2009) found that AG, PCC, and MTL were all associated with autobiographical memory, default mode network, navigation, theory of mind, and prospection.

Subdivisions that were activated for personal but not famous names were the bilateral PreS (MTL), right 7m and RSC (PCC), and the right TPOJ2 and TPOJ3 (AG). These can be thought to be especially sensitive to autobiographical recollection associated with people and places. Within PCC, the posterodorsal region is thought to have a role in episodic memory retrieval as well as allocentric spatial representation of familiar places (Burgess, 2008; Cavanna & Trimble, 2006; Freton et al., 2014). Personally familiar people are also associated with familiar places, and hence may activate episodic memories with spatial layouts. Activation of areas 7m and RSC may reflect activation of these allocentric representations and spatial navigation (Vann et al., 2009) within them. No region showed a greater response to famous entities over personally familiar entities in the three ROIs. The

ATL showed the same pattern, with the exception of the right STGa, which had a significant response for famous people, but to no other category, suggesting a non-autobiographical role.

Renoult et al. (2012) describe models differentiating between personal semantics, general semantics, and episodic memory. Activation of these semantic regions for both personal names and words provides evidence against models that make a clear categorical distinction between these types of semantics. A component process view that conceptualizes these memories as representing different weighting of various cognitive processes is supported. In the context of our task, personal and general semantics greatly overlap and involve similar processes. With appropriate explicit task demands, they are likely to be more separable.

While MTL, PCC, and AG are associated with autobiographical memories, autobiographical memories are necessarily constructed out of more general semantic content (Binder & Desai, 2011). An autobiographical memory such as ‘I ate cereal for breakfast today’ depends on understanding of concepts such as *eat*, *cereal*, *breakfast*, and *today* and cannot exist independently of these concepts. Portions of the AG/PCC/MTL network may represent these general concepts that are part of autobiographical memory, as suggested by the finding that they are also activated common names. But in addition to general semantics, events have a temporal structure. MTL, PCC, and AG are also likely to represent this temporal structure, adding components such as roles of agent and patient as well as cause and effect that links concepts together into an event. Autobiographical memories can be thought of as special cases of events in which the representations of objects and actions have especially rich sensory-motor correlates based on personal experience. The autobiographical memory of one’s own breakfast may have more vivid representations of the color, shape, texture, and taste of the cereal, the spatial layout of the kitchen table, and so on, which would be much less detailed in a generic event of breakfast eating. Greater activation of MTL and PCC can be interpreted as representing these richer visuo-spatial components of autobiographical memories. AG may have a role in activation of a greater number of features and associations, integration of these features, and linking them into a temporal structure. Fernandino et al. (2016) found that AG (along with PCC and MTL) was activated by lexical concepts rated high in any of a set of five sensory features (color, shape, motion, manipulation, sound), suggesting that it may be a heteromodal semantic hub. Thakral et al. (2017) found that during episodic simulation, AG was modulated as a function of the amount of simulated details, while MTL was not. If autobiographical memories activate constituent concept features with greater detail, it explains activation of AG in both lexical semantic and autobiographical memory tasks.

An alternative explanation for activation of classically semantic areas such as AG is that it represents lower deactivation in easier conditions. It is commonly observed that relative to rest, AG is deactivated less for less demanding conditions regardless of the nature of task or stimulus materials (Gilbert et al., 2012; Harrison et al., 2011; Humphreys & Lambon Ralph, 2017). Hence, it shows greater activation for the easy condition in an easy > hard contrast, even if the task does not involve semantic processing. Given that ‘rest’ is a richly semantic condition, a task with low demands would not suppress task-unrelated thoughts common during rest, leading to activation (or lower deactivation) of semantic and default-mode regions such as AG. Here with proper names, conditions with shorter RTs, such as personally familiar names activate AG more than famous or unknown names, which have longer RTs. A similar pattern is observed with place names. However, we do not believe that less deactivation (or greater activation of the default-mode network) can explain these results. Personally familiar people have statistically identical RT to that of personally familiar places, but the former results in greater activation. The same is true for famous people relative to famous places. Moreover, common names have lower RTs than proper names, but result in lower activation of semantic regions such as AG and PCC. Hence, richness of semantic features and episodic details associated with these concepts, rather than lower deactivation of the default-mode network, is a more plausible explanation of these activations.

Conclusions

While proper names are thought to have a special psycholinguistic status, we found that proper and common names activate largely similar areas that are often described as semantic hubs. Most subdivisions within AG, ATL, PCC, and MTL, bilaterally were activated by both proper names and common names in the same participants. Area PGi within AG, and the right ATL showed greater response with greater associated knowledge, pointing to an associative or thematic role. The right perirhinal and entorhinal cortex showed a response specific to proper names, suggesting an item-specific role in retrieving person and place related information that does not generalize to common names. Activation to person and place names also overlapped greatly. Place names were differentiated by activating areas associated with spatial memory and navigation. Person names showed more bilateral activity with greater right hemisphere involvement compared to places, possibly showing a wider range of associations. Finally, personally familiar names showed stronger activation bilaterally compared to famous names in all four regions, indicating representations that are enhanced by autobiographic and episodic details. Both proper and common names are processed in the wider semantic system that contains associative, episodic, and spatial components.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability:

The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request.

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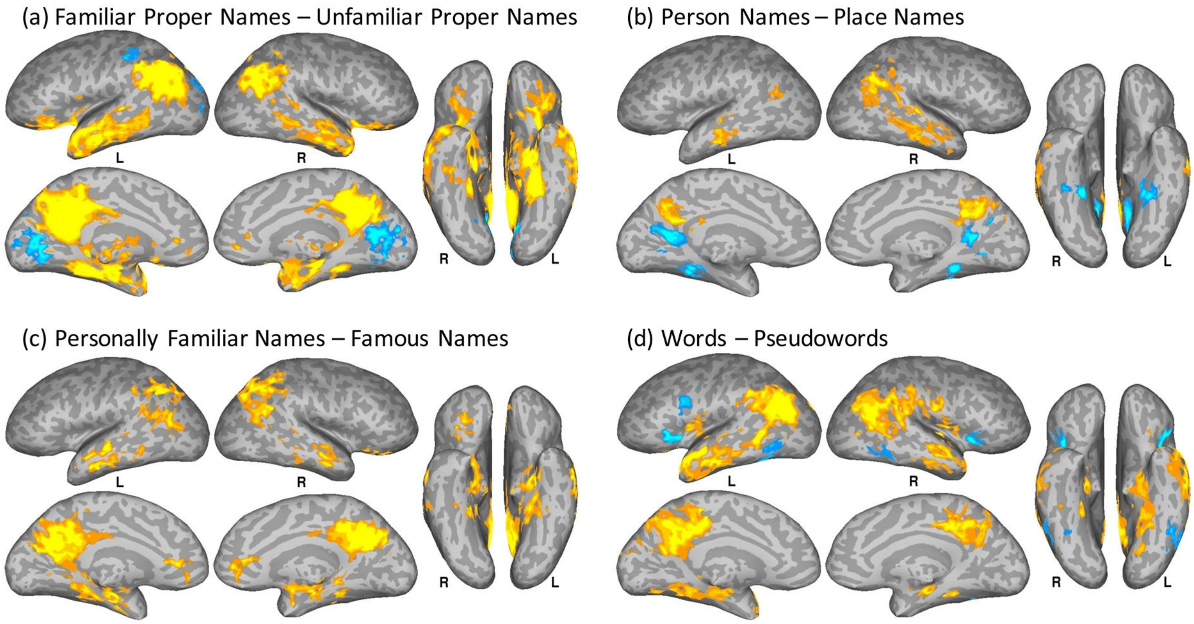

Figure 1.

Whole-brain responses to contrasts of (a) familiar and unfamiliar names, collapsed across people/place and personally familiar/famous names. (b) Person and place names, collapsed across personally familiar/famous names. (c) Personally familiar and famous names, collapsed across people/places. (d) Words and pseudowords. Yellow-orange scale indicates greater activation to the first condition in the contrast, while the blue-cyan scale indicates greater response to the second condition.

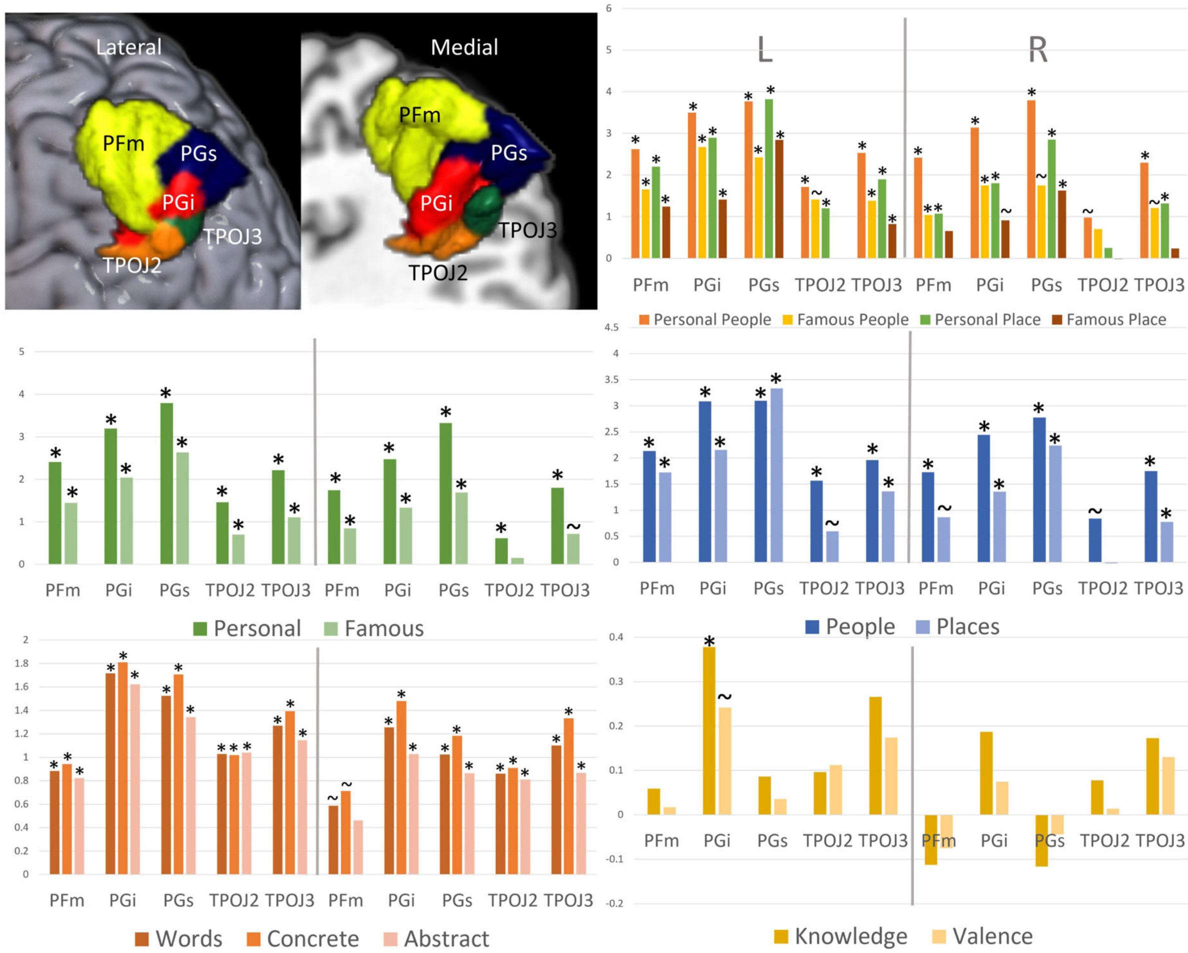

Figure 2.

Responses to proper and common names in subdivisions of angular gyrus. Subdivisions were determined according to the Human Connectome Projects (HCP) atlas. Proper names are contrasted with corresponding unfamiliar names, while word responses are relative to pseudoword response. Y-axis shows normalized beta coefficients. * indicates significance at $p < 0.05$ level after correction for multiple comparison within the ROI (each $p < 0.005$). ~ indicates trending significance, with values between $p < 0.025$ and $p < 0.005$.

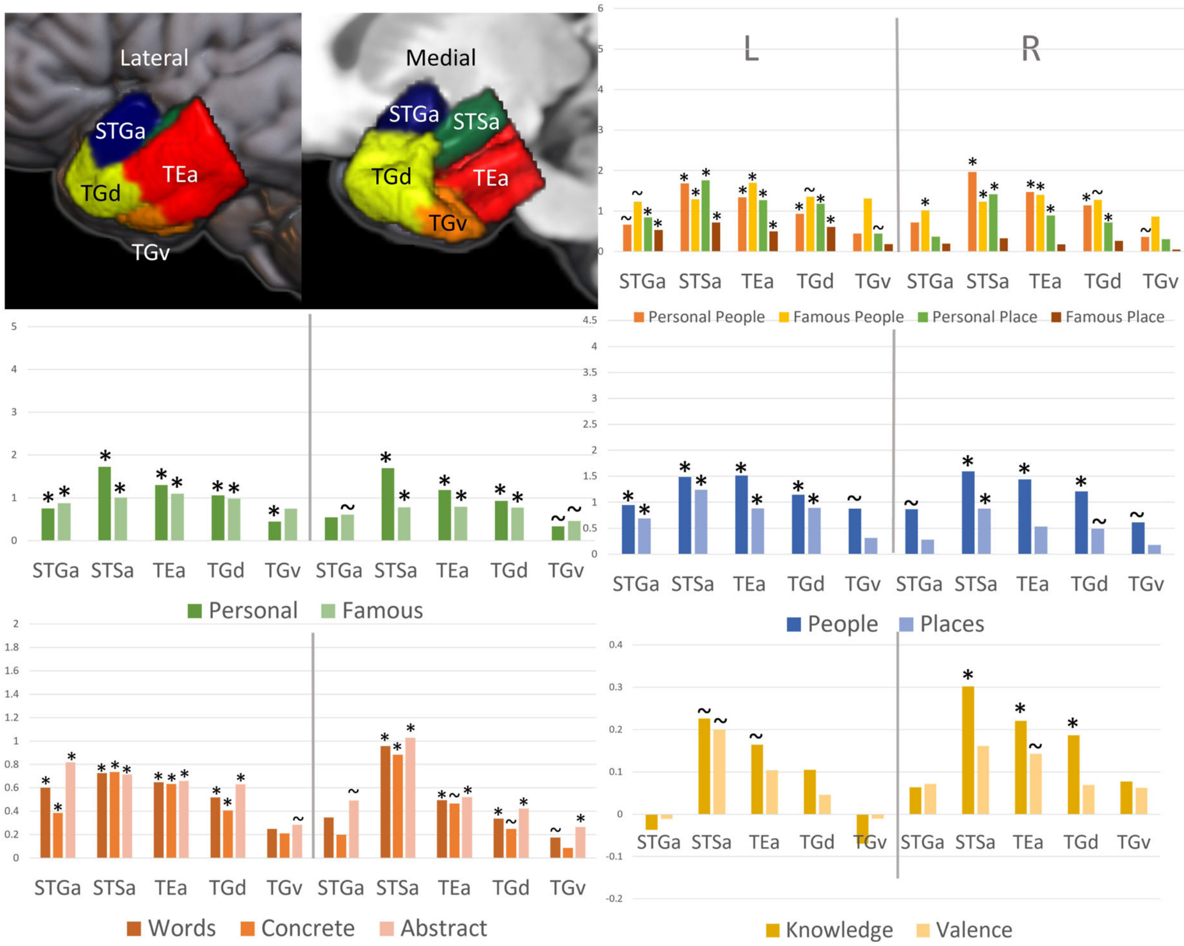

Figure 3.
Responses to proper and common names in subdivisions of lateral anterior temporal lobe (see Figure 2 caption for details).

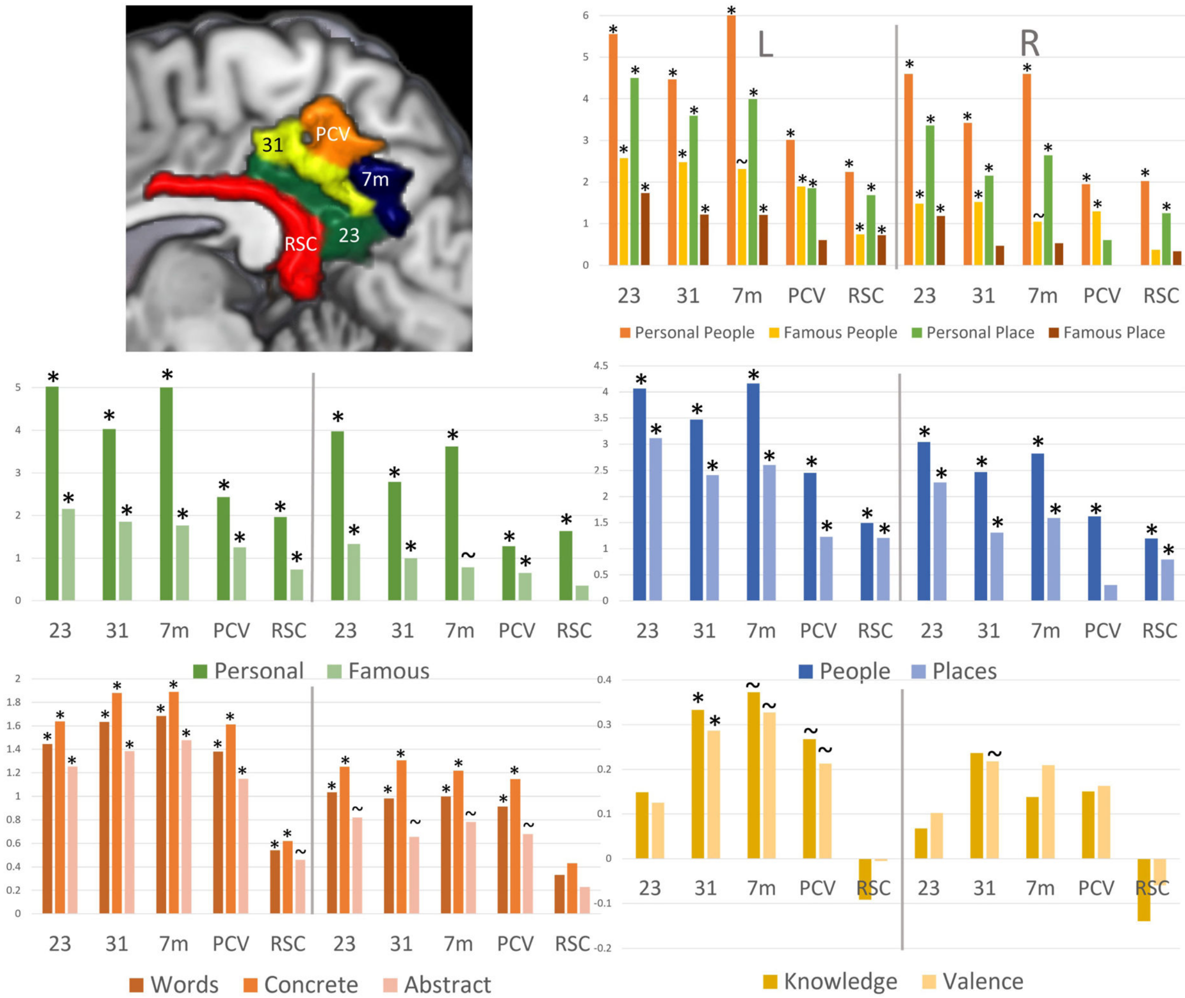

Figure 4.

Responses to proper and common names in subdivisions of the posterior cingulate complex (see Figure 2 caption for details).

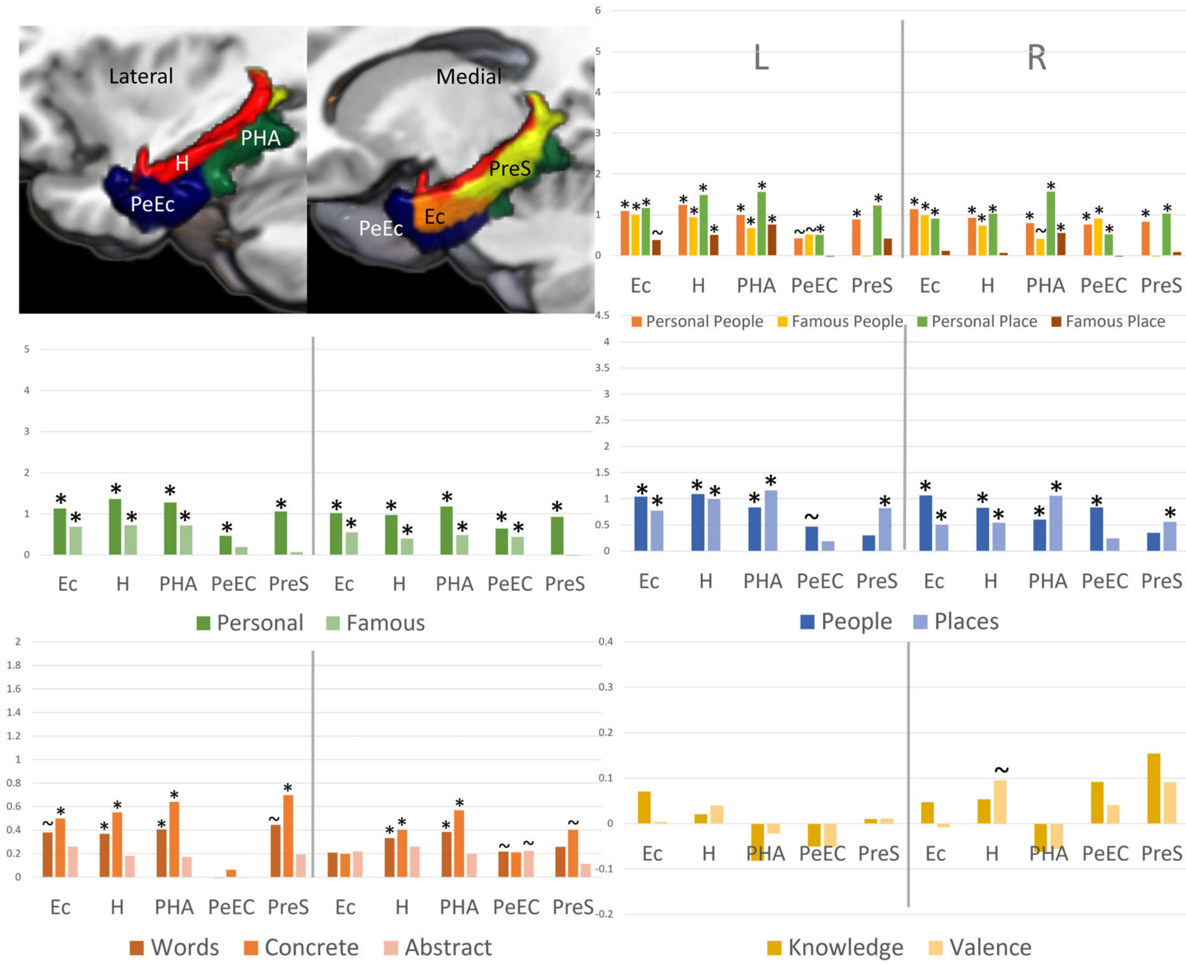

Figure 5.
Responses to proper and common names in subdivisions of medial temporal lobe (see Figure 2 caption for details).

Table 1.

Familiar vs. Unfamiliar Proper Names. Activation tables shows volume of the cluster in mm^3, the mean z-score of each cluster, peak z-score, and Talairach coordinates of the peak for each cluster. Note that many clusters are large and span multiple anatomical areas. The anatomical label refers only to the peak coordinate, and is not descriptive of the extent of the cluster.

Familiar Names > Unfamiliar Names	Volume	Mean	Max	x	y	z	
	42341	3.36	5.9	−25	−37	−9	L FG
	31199	4.06	6.726	−4	−55	27	L Precuneus
	25042	3.17	5.941	27	−32	−6	R Hippocampus
	23513	4	5.709	−43	−68	35	L AG
	19093	3.49	5.098	46	−72	28	R AG
	816	2.99	3.919	−1	38	−1	L ACG
Unfamiliar names > Familiar Names							
	1132	−2.91	−3.925	−45	−30	38	L Post central sulcus

Table 2:

Main effect of type (People vs. Place Names).

Familiar people > Familiar places							
	Volume	**Mean**	**Max**	**x**	**y**	**z**	
	14314	3.04	5.116	45	−56	26	R AG
	7561	3.25	4.808	5	−49	24	R PCG
	1893	3.02	5.105	−59	−17	−14	L MTG
Familiar places > Familiar people							
	Volume	**Mean**	**Max**	**x**	**y**	**z**	**Structure**
	2235	−3.43	−5.064	11	−51	8	R Calcar. sulcus
	2162	−3.36	−4.834	−11	−54	12	L POS
	1333	−3.4	−4.774	25	−34	−10	L OTS
	1305	−3.15	−4.724	−28	−38	−8	R OTS

Table 3:

Main effect of familiarity (Personally familiar vs. famous names).

Personally familiar > Famous names	Volume	Mean	Max	x	y	z	
	32021	3.59	5.899	7	−58	28	R Precuneus
	15544	3.29	5.362	30	−71	36	R Precuneus
	4796	3.19	5.376	−26	−17	−15	L Hippocampus
	3991	3.03	4.268	−45	−65	16	L MTG
	3270	3.26	5.203	−50	−16	−6	L STS
	3091	3.11	4.509	29	−33	−7	R Hippocampus
	2300	3.15	4.607	58	−8	−16	R MTG
	2249	3.19	4.73	−5	37	5	L ACS
	1252	3.15	4.494	32	25	−9	R IFG (p.orb)
	886	2.9	3.729	−63	−43	−4	L MTG

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Table 4:

Words vs. Pseudowords.

Words>Pseudowords							
	Volume	**Mean**	**Max**	**x**	**y**	**z**	**Structure**
	32355	3.47	6.405	−45	−68	23	L AG
	23541	3.29	5.625	56	−62	15	R AG
	22629	3.32	5.05	−3	−32	36	L MCC
	7681	3.09	4.411	28	−19	−13	R Hippocampus
	4394	3.05	4.083	−25	−47	−8	L FG
	2668	3.06	4.6	64	−11	15	R post central gyrus
	1828	2.99	4.016	−32	−5	1	L Putamen
Pseudowords>Words							
	Volume	**Mean**	**Max**	**x**	**y**	**z**	**Structure**
	1373	−3.48	−4.915	−34	19	5	L Insula
	952	−3.41	−4.872	31	20	2	R Insula