

computations that support each one). The results were used to test 5 potential organizational principles that emerge from the literature (summarized later) as well as specific theories.

1. “Splitting versus lumping neurocognitive functions”: The parietal cortex occupies a large region with multiple cyto-architectural and connectivity variations. Thus, some researchers have argued that, like a form of neurofunctional marquetry, the parietal cortex is divided into many different domain-specific processing areas each with sharp dissociations in function (Simon et al. 2002; Hutchinson et al. 2009; Nelson et al. 2010; Nelson et al. 2012). Within this “fractionated” view, proposed anatomical-functional pairings include IPS and number processing, SMG with tool-related tasks or phonological processing, and angular gyrus for episodic recollection or semantic processing. In contrast, the “overarching” accounts emphasize greater functional unification reflected in overlapping fMRI activation and co-occurring neuropsychological deficits (Head 1926; Luria 1976; Corbetta and Shulman 2002; Jefferies and Lambon Ralph 2006; Cabeza et al. 2008; Ciaramelli et al. 2008; Duncan 2010; Cabeza et al. 2012; Crittenden and Duncan 2014; Kim 2012; Noonan et al. 2013). The key notion here is that a limited number of underlying neurocomputational processes support multiple behavioral domains.
 2. “Dorsal versus ventral parietal cortex”: Classical neuropsychological data clearly suggest a dorsal versus ventral division of function (e.g., ideomotor vs. ideational apraxia, Bálint’s vs. Gerstmann’s syndromes, etc.: Buxbaum et al. 2006; Vallar 2007). Likewise, functional neuroimaging also suggests a similar division for many different domains (e.g., executive vs. automatic semantic processing, number computations vs. fact recall, familiarity vs. recollection in episodic memory, top-down vs. bottom-up attention, etc.: Corbetta and Shulman 2002; Delazer et al. 2003; Vilberg and Rugg 2008; Whitney et al. 2009; Kim 2010; Noonan et al. 2013). Furthermore, dorsal and ventral areas show different patterns of effective and structural connectivity; dorsal areas form part of a fronto-parietal control system, whereas ventral areas connect with a distributed set of regions associated with the default-mode network (DMN) (Vincent et al. 2008; Spreng et al. 2010; Uddin et al. 2010; Cloutman et al. 2013; Power and Petersen 2013). The dorsal-ventral dimension is orthogonal to the fractionation-unification distinction in that dorsal-ventral differences have been proposed for many individual behavioral domains. Indeed, Bálint’s and Gerstmann’s syndromes each comprise multiple, superficially unrelated neuropsychological deficits—which might reflect tightly yet separately packed neural functions (i.e., fractionation) or an impairment to a generalized neurocomputation that multiple domains rely upon (i.e., unification).
 3. “Anterior versus posterior parietal cortex”: There is evidence for an anterior (SMG)–posterior (AG) dimension. Supramarginal and angular gyri and AG show distinct patterns of connectivity (Uddin et al. 2010; Cloutman et al. 2013) whereas neuropsychological and functional neuroimaging studies suggest a dissociation. In language, SMG tends to be implicated in phonological tasks more than semantics, whereas AG shows the opposite (Price et al. 1997; Devlin et al. 2003). Likewise, in the aphasia literature, conduction aphasia (impaired repetition but intact semantics) is associated with inferior SMG damage (Dronkers et al. 2004; Fridriksson et al. 2010) whereas the opposite pattern (transcortical sensory aphasia) follows from lesions outside of SMG in the watershed territory from IPS through AG to PMTG (Berthier 1999). Outside of the language domain, however, some researchers have argued against strong SMG–AG dissociations, arguing instead for graded functional overlap (Cabeza et al. 2012). Indeed, recent functional connectivity studies find evidence for graded AG–SMG differences rather than strong dissociations (Daselaar et al. 2013).
 4. “Positive versus negative activations”: Unlike most other cortical regions, VPC is associated with the DMN (Buckner et al. 2008; Mantini and Vanduffel 2013); this region plus medial frontal and posterior cingulate areas demonstrate “deactivation” when compared with “rest.” Interpretation of deactivation is inherently tricky, and various possible explanations include switching between internal and externally directed cognitive processing (Buckner et al. 2008), or the vibrant semantic-language activity of inner thought, associated with “rest”, is reduced when participants shift into goal-directed non-semantic experiments (Binder et al. 1999). For a complete understanding of parietal functions, it is important to establish the relationship between the DMN and the other behavioral domains. As a first step, we asked the following initial questions: 1) what is the overlap between the parietal component of the DMN and the many behavioral domains associated with the parietal region, 2) do all parietal regions deactivate, and 3) do DMN-parietal regions always deactivate or are positive activations within the same areas sometimes observed?
 5. “Laterality”: A final potential dimension of parietal organization reflects left versus right hemispheric differences. Chronic disorders of language or apraxia are associated with left parietal damage whereas long-term visuospatial attention impairments (e.g., neglect) tend to follow from right parietal lesions (Mesulam 1999). This pattern appears to be mirrored in some neuroimaging studies, which have shown right hemisphere activation for attention (Corbetta and Shulman 2002), whereas episodic retrieval and language exhibit left-hemisphere engagement (Vigneau et al. 2006; Hutchinson et al. 2009). While these data suggest that left- and right-hemispheres might serve distinct functions, the strength of these differences is unclear. First, although chronic disorders of visuospatial attention, language, and apraxia are associated with a laterality effect, in the acute phase neglect and aphasia can be observed after left or right lesions (Hier and Kaplan 1980; Kleinman et al. 2007). In addition, few functional neuroimaging studies have conducted formal statistical laterality comparisons. Indeed, even in behavioral domains associated with strong laterality effects, many examples of bilateral activation can be found (Downar et al. 2001; Homae et al. 2002; Herron et al. 2004; Weis et al. 2004; Serences et al. 2005; Mayer et al. 2006; Hutchinson et al. 2014; Vilberg and Rugg 2012).
- To assess the principles of parietal organization, we undertook a large-scale, multi-domain meta-analysis based on the considerable functional neuroimaging data that are now available in the literature (see Materials and Methods). We define “behavioral domains” here as a way of categorizing/differentiating different behaviors or higher mental activities (e.g., language behaviors, number decisions, object-use behaviors, etc.). Each of these will be underpinned by a combination of domain-