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Cultural and linguistic influence on neural bases of 'Theory of Mind': An fMRI study with Japanese bilinguals

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Abstract

Theory of mind (ToM)—our ability to predict behaviors of others in terms of their underlying intentions—has been thought to be universal and invariant across different cultures. However, several ToM studies conducted outside the Anglo-American cultural or linguistic boundaries have obtained mixed results. To examine the influence of culture/language on neural bases of ToM, we studied 16 American English-speaking monolinguals and 16 Japanese-English bilinguals with second-order false-belief story tasks, using functional magnetic resonance imaging (fMRI). Several neural correlates of ToM including medial prefrontal cortex (mPFC) and anterior cingulate cortex (ACC) were recruited by both cultural/linguistic groups. However, some other brain areas including inferior frontal gyrus (IFG) were employed in a culture/language-specific manner, during the ToM tasks. These results suggest that the ways in which adults understand ToM are not entirely universal.

Keywords: Theory of mind; Cognition; Japanese; Culture; Language; Bilingualism; fMRI

1. Introduction

Theory of mind (ToM) has been defined as the ability to impute mental states to others (Premack & Woodruff, 1978). This ability to understand others' desires and intentions that can be different from one's own is a critical and perhaps uniquely human capacity (Frith & Frith, 2003). ToM has been tested extensively with false-belief tasks in normally developing (Wimmer & Perner, 1983) and atypical pediatric populations (Baron-Cohen, Leslie, & Frith, 1985). In a typical first-order false-belief task, two characters appear (e.g., Sally and Ann) in a scene. When one character, Sally, is present, Ann, the other character, puts a toy into a basket. Sally then disappears from the scene. While Sally is away, Ann takes the toy out of the basket and puts it into a box. The experimenter then asks the subject the critical false-belief question, 'Where will Sally look for the toy?' Nearly universally observed results are that adults and children over 4 years of age correctly answer 'basket' whereas younger children and children with autism fail the task by answering 'box' (Baron-Cohen et al., 1985, Baron-Cohen, Leslie, & Frith, 1986). The failure reflects their lack of understanding of the false-belief that Sally's belief about the location of the toy is different from Ann's.

Because the age for passing the first-order false-belief task is often significantly delayed in children with autism (Happé, 1995), it has been hypothesized that ToM has an innate biological basis (Frith & Frith, 2001; Scholl & Leslie, 1999), and that this 'core' basis of ToM is universal (Fodor, 1983; Scholl & Leslie, 1999; Leslie, Friedman, & German, 2004). However, the universal ToM hypothesis has not been uncontested, because several ToM studies conducted outside the Anglo-American cultural or linguistic milieus have obtained mixed results. Some of these

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cross-cultural studies have supported the universal developmental trajectory of ToM (Avis & Harris, 1991; Lee, Olson, & Torrance, 1999; Naito, Komatsu, & Fuke, 2004; Tardiff & Wellman, 2000), whereas others have found some delays in ToM for the non-English speaking children (Chen & Lin, 1994; Louis, 1998; Naito, 2003; Vinden, 1996). Authors of the latter cases have given linguistic or cultural differences as explanations for the below-chance performance of the non-English speaking children. For instance, Junin Quechua children's poor ToM performance has been attributed to their lack of mental state verbs (Vinden, 1996). Similarly, below-chance ToM performance in 4- and 5-year-old Japanese children has been attributed to differences between American/European and Asian cultural attribution styles (Naito, 2003); specifically, people brought up in American/European cultures tend to attribute behaviors to internal causes, while people raised in Asian cultures tend to attribute them to external and contextual causes (Masuda & Nisbett, 2001; Nisbett, 2003). These findings lead to an important question. If there is some difference in ToM performance in children living in different cultures, do adults, who should have developed the *folk psychology* (i.e., adult version of ToM) adapted to their specific cultural and linguistic environment (Astington, 1996; Lillard, 1998), exhibit even more variability in the ToM performance? Likewise, have these adults developed neural bases of ToM specific to their cultural or linguistic environment?

Several brain imaging studies have examined the neural correlates of ToM (Brunet, Sarfati, Hardy-Baylé, & Decety, 2000; Calarge, Andreasen, & O'Leary, 2003; Fletcher et al., 1995; Gallagher et al., 2000; Gallagher, Jack, Roepstorff, & Frith, 2002; Goel, Grafman, Sadato, & Hallet, 1995; Happé et al., 1996; McCabe, Houser, Ryan, Smith, & Trouard, 2001; Sabbagh & Taylor, 2000; Saxe & Kanwisher, 2003; Vogeley et al., 2001). Many of these studies have found significant activity in medial prefrontal cortex (mPFC) during ToM conditions (Calarge et al., 2003; Fletcher et al., 1995; Gallagher et al., 2000; Goel et al., 1995; Happé et al., 1996; Saxe & Kanwisher, 2003). More recently, however, the temporo-parietal junction (TPJ) has been suggested to be important for ToM processing because this area was found to become activated during both true- and false-belief conditions and not during false representations in a non-social control condition (Saxe & Kanwisher, 2003; Saxe & Wexler, 2005). An alternative view is that this area might be involved in more general ability of distinguishing self-agency from other agency (Blakemore & Frith, 2003; Jackson & Decety, 2004; see also Decety & Grèzes, 2006 for a review).

In terms of the functional relationship between language and ToM, neurological studies that examined a relationship between neural correlates of ToM and those of language obtained mixed results. On the one hand, a severe aphasic patient, who had wide-range of left hemisphere damage, showed intact performance in some non-verbal ToM tasks, despite failing all other syntax-related tasks (Varley & Siegal, 2000). On the other hand, a few studies found activations in brain areas that were normally dedicated to language (e.g., Broca's area) when subjects imitated intentional behaviors (that are considered to be a lower-level ToM processing) (Iacoboni et al., 1999; see also Refs. in Chaminade, Meltzoff, & Decety, 2002). Moreover, evidence suggests that processing of pragmatically coherent sentences also recruits the mPFC area primarily (Ferstl & von Cramon, 2002). These results suggest that some aspects of language (e.g., grammar) may function merely as a 'co-opted' system (see Siegal & Varley, 2002), but other aspects of language (e.g., pragmatics and reading communicative intentions) may profoundly affect ToM throughout the development.

To better understand the possible linguistic/cultural effects on ToM and the neural correlates that may support the claim, a comparison between groups with different languages and cultural backgrounds is needed. Previous neuroimaging studies of ToM include two with non-native English speakers (Swedish individuals with Asperger's syndrome (Happé et al., 1996) and German adults (Vogeley et al., 2001)). However, neither study was designed to compare these subjects with speakers of another language (e.g., English). No study to date has explored the possible variability in ToM depending upon the cultural and linguistic backgrounds of the subjects.

The present study sought to explore these possible cultural variations in the neural correlates of adults' ToM (a.k.a., *folk psychology*) by examining Japanese-English late bilinguals and English speaking monolinguals. We recorded the hemodynamic response of the subjects during both English and Japanese second-order false-belief ToM stories (Fig. 1), non-ToM control stories, and scrambled sentences, using fMRI. We predicted that if ToM has a universal neural basis, some significant overlap in brain activation patterns would be found among the three task-groups (monolingual English speakers, bilingual subjects viewing Japanese stories [L1], and bilingual subjects viewing English stories [L2]) in candidate ToM brain areas (e.g., the mPFC (Frith & Frith, 2003) and the TPJ (Saxe & Kanwisher, 2003)).

Furthermore, by comparing between different linguistic/cultural groups, we wished to find neural correlates of ToM that might vary depending upon the cultural- and/or linguistic background of the subject. Our specific hypotheses were as follows.

1.1. Cultural effects on ToM

Any brain regions that have a greater activity during both the Japanese L1 and L2 task-groups than the American monolingual's task-group may be important for understanding ToM for the Japanese culture. Conversely, any brain regions with greater activity during American monolingual's task-group than Japanese L1 and L2 task-groups may be important for understanding ToM for the American culture.