Common Neural Effects of Spatial, Temporal, Social, and Hypothetical Distance

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INTRODUCTION

Human bodies are restricted by subjective perceptions of the here and now. Yet the human mind has a unique capacity to transcend the body through spatial, temporal, social, and hypothetical distance. The default network has been identified as the neural basis of this capacity for simulation, or self-projection into any dimension (Buckner & Carroll, 2007; Simon et al., 2009). However, research on psychological distance suggests that people richly represent only proximal events during spontaneous simulation and thus should not recruit the default network as robustly during simulation of distal events (Gallagher & Frith, 2007; Vallacher & Wegner, 1991).

HYPOTHESES

Using neural and implicit measures of psychological distance, here we test two predictions:
1) The default network distinguishes simulation of near and far events
2) The default network processes distance the same in all four dimensions: spatial, temporal, social, hypothetical

METHODS

PARTICIPANTS
• N = 21 (mean age: 21.3 yr, range: 19-25; 13 female)

IMPLICIT ASSOCIATION TEST
• Near and far category labels from two dimensions are paired with each other. Pairs are either “congruent” (e.g., Here-Now & There-Later) or “incongruent” (e.g., Here-Later)
• Participants categorize stimuli (e.g., domestic, present, abroad, after) into label pairs
• One IAT for each of 6 possible dimension pairings; 60 trials each; order randomized
• The speed with which participants can respond during congruent versus incongruent pairings provides a measure of 1) Implicit associations between each of the four dimensions: spatial, temporal, social, hypothetical, and 2) dissociation between near and far distance with each other dimension

IMAGING TASK
• During scanning, participants respond to statements about preferences and activities
• On each trial, participants consider a preference statement from either proximal or distal perspective within one of four dimensions (order randomized):
  • Spatial
  • Temporal
  • Social
  • Hypothetical

IMAGING PROCEDURE
• 3T Siemens Trio MRI scanner (12 channel coil)
• Gradient-echo BOLD sequence (TR = 2s; TE = 35 ms)
• 31 interleaved slices, 3mm thick, 1mm skip
• 268-s runs for each of the 4 dimensions; 100 trials in each run; event-related design

RESULTS

IMPLICIT ASSOCIATION TEST

Participants responded more quickly during congruent blocks than incongruent blocks (all t(20) > 5.4, all p < .001)
1) Strong implicit associations among all four dimensions of distance with each other dimension
2) Strong implicit distinction between proximal and distal concepts, across all dimensions of distance

IMAGING TASK

Near versus Far

Spatial
Temporal
Social
Hypothetical

1) Wholebrain random effects analysis NEAR > FAR (p < .05 corrected): Bold response in MPFC and PCC is greater for near than far conditions during all four distance tasks
2) Behavioral responses for near trials differ from far trials in all dimensions (all p’s < .01)
3) Reaction times did not differ by perspective
4) No region consistently showed greater activity for far conditions across all four distances

Conjunction across Dimensions

Conjunction analysis identified voxels common to all four distance tasks for NEAR > FAR contrast: Analysis conducted using xjView at voxel-wise alpha level of .05 (yellow), .025 (red), and .01 (green)
1) Conjunction analyses reveal significant overlap in MPFC (k=450 voxels) and PCC (k=150 voxels) and .01 (green)
2) BOLD differences in MPFC between near and far conditions correlate across dimension tasks (mean r=.25, p=.01): participants whose MPFC distinguishes between near and far the most for one dimension also strongly distinguish between near and far across the other dimensions

IMPLICIT ASSOCIATION TEST

Composite IAT score calculated as the mean difference between incongruent and congruent blocks across all six IAT tasks
Composite parameter estimate calculated as mean BOLD difference between near and far conditions across four distance tasks

BRAIN-BEHAVIOR CORRELATIONS

Composite IAT score correlates with neural activity difference between near and far distance with each other dimension

CONCLUSIONS

1) The default network distinguishes between spontaneous simulations of near versus far events
2) People implicitly distinguish between near and far across all dimensions
3) The MPFC and PCC process distance the same, regardless of dimension
4) People show implicit associations between all dimensions
5) Individual differences in engagement of the MPFC reflect individual differences in implicit psychological distance