Saving for the future self:

Neural measures of future self-continuity predict temporal discounting

ONLINE SUPPLEMENT

Scoring the Temporal Discounting Task

Subjects indicated their preference by pressing the left or right button on a computer mouse, with a subsequent opportunity to revise their choice. At the experiment's conclusion, the experimenter selected one trial at random, and the subject received their choice on that trial. If subjects had chosen the delayed gain, they received a dated "I Owe You" for that amount, which they were mailed on the appropriate date, otherwise, they received cash corresponding to the immediate gain.

As in Mitchell (1999), to determine each subject's switch point, the immediate gains were arranged in descending order of value ($10.50 to $0.01). The data were then coded according to the subject's preferences: immediate or delayed. When the delayed gain was high (e.g., $10.50), subjects usually preferred it, as well as when the immediate gain was low (e.g., $0.01). Generally, the option value at which preference switched was discrete. As in previous research (Mitchell, 1999), 68% of the delayed gains showed a discrete preference switch. For the remaining 32% of the delayed gains, preference switched between the delayed and immediate gains before subjects reliably preferred the delayed gain. In these instances, subjects were coded as possessing a preference for the delayed gain at the highest value of the immediate gain for which the delayed gain was preferred over the same value and the next lowest value of the immediate gain. Then the switch point was defined as midway between the lowest value of the immediate gain preferred ($8.50) and the highest value of the immediate gain rejected ($8.00).

To assess individual differences in temporal discounting, we estimated the gradient of the function describing the switch points plotted as a function of delay. If one individual values future gains less than another individual, he or she should show a steeper discount parameter (*k*). The hyperbolic equation described in the introduction was fitted for each participant's switch point data (Mazur, 1987) using the Solver subroutine in Microsoft Excel 2003 (Mitchell, 1999).

Valence Analyses

Endorsement. A repeated-measures ANOVA with three within-subjects factors (Person: self, other; Time: current, future; Valence: positive, negative) examined whether trial type influenced endorsement of trait words. A main effect of Valence indicated that positive words were endorsed as being more descriptive of all target than negative words, $F(1,17) = 53.42$, $p < .001$. A Person x Time x Valence interaction, $F(1,17) = 19.95$, $p < .001$, indicated that subjects endorsed positive words that applied to the future self as being more descriptive than positive words that applied to the current self, $t(17) = -3.94$, $p < .001$. For the 'other' target, positive words that applied to the current other and future other did not differ, $t(17) = -.46$, $p = .65$.

Brain Activation. A main effect of Valence (positive vs. negative) correlated with activation in the rACC (z=-3.92; -15,41,12; Table 2). However, no VOIs showed activation which correlated with the remaining interaction coefficients for Valence (Person x Valence, Time x Valence, Person x Time x Valence).

References

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In J. Commons, J. E. Mazur, J. A. Nevin & H. Rachlin (Eds.), *The effect of delay and of intervening events on reinforcement value* (Vol. 5, pp. 55-73). Hillsdale, NJ: Lawrence Erlbaum.

Mitchell, S. H. (1999). Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology (Berl), 146*(4), 455-464.

Supplemental Table 1.

Regions correlated with the full factorial model * = region survives , p<.001, uncorrected , 2 voxel cluster. * denotes a priori regions significant at p<.005, 2 voxel cluster.

Region	X	Y	Z	z-Score
Person (Self > Other)				
L Frontal pole	-15	64	4	3.64
R Middle frontal gyrus	26	49	12	4.02
L Dorsomedial prefrontal cortex	-4	45	16	4.90
R MPFC / Rostral ACC	3	44	-3	3.83
L MPFC / Rostral ACC	-4	38	-3	5.39
L Middle frontal gyrus	-23	38	38	4.90
	-45	8	38	3.62
L Anterior cingulate	-4	19	27	3.93
R Caudate	8	19	8	3.56
L Nucleus Accumbens	-8	15	3	5.14
R Nucleus Accumbens	6	17	-3	3.95
L Superior frontal gyrus	-8	11	49	4.25
R Dorsal caudate	11	4	12	3.85
	11	-8	16	3.84
L Dorsal caudate	-11	0	16	3.82
L Thalamus	-4	-11	12	3.75
L Cingulate	-4	-15	34	4.36
L Hippocampus	-23	-23	-3	3.85
L Superior temporal gyrus	-49	-26	1	3.90
L Parahippocampal gyrus	-8	-34	12	3.63
R Inferior parietal lobe	30	-38	53	4.53
	30	-38	42	4.17
L Middle temporal gyrus	-45	-41	8	4.63
L Posterior cingulate	-4	-49	8	3.82
L Precuneus	-23	-49	49	4.32
	-4	-56	49	3.47
	-19	-79	34	4.04
R Precuneus	11	-56	53	3.81
	26	-64	34	4.74
	30	-75	38	3.54
R Cuneus	23	-79	31	3.89
Time (Current > Future)				
L Superior temporal gyrus	-49	11	-3	3.72
R Postcentral gyrus	45	-19	38	3.76
L Inferior parietal lobe	-38	-30	42	3.87
L Midbrain	-8	-30	-11	3.51

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L Precuneus	-19	-45	49	3.68
R Posterior cingulate	4	-53	8	4.16
R Superior parietal lobe	26	-64	46	3.64
Valence (Positive > Negative)				
L Middle frontal gyrus	-38	53	19	3.64
L Anterior cingulate	-15	41	12	-3.92
L Precentral gyrus	-49	0	12	3.43
	-41	-11	31	3.78
R Postcentral gyrus	64	-23	34	3.30
R Posterior cingulate	4	-68	16	3.71
R Cuneus	8	-75	16	3.46
Person x Time				
R Rostral ACC*	3	37	0	3.41
L Rostral ACC*	-9	37	1	3.10
Person x Valence				
R Cuneus	11	-79	12	-3.65
Time x Valence				
R Globus pallidus	26	-11	-3	4.00
Person x Time x Valence				
L Inferior frontal gyrus	-45	4	27	-3.99
L Precentral gyrus	-34	-4	27	-4.57
R Inferior parietal lobe	30	-45	53	-4.28
R Precuneus	8	-56	57	-3.93
L Precuneus	-15	-68	34	-3.64
R Middle temporal gyrus	41	-68	31	-3.84

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Supplemental Figure 1. Greater neural activation in MPFC and ACC regions for self vs. othertrials, p < .001 uncorrected.

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