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Social Discounting: An Examination of the Neural and Behavioral Performance of Individuals Making Altruistic Decisions about Family Members

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SOCIAL DISCOUNTING: AN EXAMINATION OF THE NEURAL AND

BEHAVIORIAL PERFORMANCE OF INDIVIDUALS MAKING ALTRUISTIC DECISIONS ABOUT FAMILY MEMBERS

by

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ABSTRACT

Social Discounting: An Examination of the Neural and Behavioral Performance of Individuals Making Altruistic Decisions about Family Members

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Social Discounting is defined as the decrease in generosity between the decision maker (participant) and the recipient of a gift as social distance (perceived closeness) between the two increases. To date, there is little data that has been collected that compares both the responses of behavioral performance and the corresponding neural activity when individuals are asked to make decisions about money based upon how close they feel to someone of their kin or not of their kin as their perceived social distances or relationships change. This specific study includes both fMRI and behavioral data analysis and takes into account the difference in perceived social distance between kin and non-kin relationships in correspondence with blood flow to specific areas of the brain that are being activated when participants are asked to make decisions regarding altruistic or self-motivated decisions. Analysis of the imaging data collected showed 4 main regions more active when participants imagined how they would feel receiving a gift versus giving the gift. These active regions were observed within the right superior temporal gyrus, right middle frontal gyrus, BA8 in the frontal cortex, and the left superior frontal gyrus.

KEYWORDS: social discounting, altruism, imaging, kin/non-kin, fMRI

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Social Discounting: An Examination of the Neural and Behavioral Performance of Individuals Making Altruistic Decisions About Family Members

1. Introduction

Humans are social beings. It is nearly impossible for an individual to go about his or her daily life without coming into contact with another human being, thus having to interact with others on a social level on a day-to-day basis. Additionally, humans are constantly confronted with different situations in which they are forced to make decisions. The way we make decisions shapes the course of our lives. Because of this, understanding the basis for social interaction and decision-making is necessary in understanding how humans function throughout their day-to-day lives. Though many of us have a tendency to occasionally make pro-social decisions, individuals are quite obviously not keeping others in their thoughts when making all decisions (Strombach T, et al., 2015). Instead, an individual's ability to be generous is dependent on the closeness of the relationship between the two individuals; generosity decreases as the the closeness of a relationship increases (Jones & Rachlin, 2006; Goeree JK et al., 2010; Strombach T, et al. 2015). This idea is the underlying basis for social discounting.

1.1. Social Discounting

Social discounting is formally defined as the decrease in generosity between the decision maker and the recipient as the social distance between the two increases (Jin, et al. 2017). In terms of social discounting, social distance is dependent upon an idea of perceived closeness to another individual. For example, social distance would be closer or smaller for your mother, father, or child than it would be in comparison to the social distance for someone you have never met before. Here, the concept of discounting is related to an idea of selfish or self-motivated behavior versus altruistic behavior. How altruistic or self-motivated an individual chooses to be in their decision making is ultimately related to how close they perceive themselves to be to that individual socially.

In prior research, it has been determined that individuals will choose to forgo keeping a specific, hypothetical amount of money for themselves in order to give a pre-determined amount of money to another person. The amount of money that an individual is willing to forgo varies in a way that reflects the perceived social closeness of the receiver of the hypothetical amount of money (Jones & Rachlin, 2006). According to Strombach et. al. (2015), it has been repeatedly confirmed that an individual's generosity declines hyperbolically across varying social distance; individuals are continually more willing to give up a reward for themselves in exchange for a pay-off for someone at a close social distance. Behavioral studies of social discounting have been completed at a much higher rate than neuroimaging studies of similar subject matter (Hill, et al., 2017).

1.2. Neural Responses to Decision Making and Social Discounting

Existing research has suggested that there are specific areas of the brain associated with gift-giving and social discounting. Areas of the brain associated with decision making, gift-giving, and social discounting can include the reward and decision-making centers of the brain located primarily in the frontal lobe. Strombach, et al (2015) explains that in their social discounting fMRI study, areas of activation in the brain differed when an individual was making a generous (altruistic) decision in comparison to when the same individual was making a self-motivated decision (Strombach, et. al., 2015). It was found that brain activity was significantly more prominent in the ventral medial prefrontal cortex when individuals were making generous, more altruistic choices (Strombach, et.al. 2015). It is suggested through other literature that perhaps the reasoning for this more prominent activation is due to the fact that the ventral medial prefrontal cortex coded generous behavior in a way that included the value of a selfish decision in addition to patterns of generosity, perhaps reflecting the personal satisfaction one achieves knowing that he or she improved the quality of life for another individual (Harbaugh & Burghart, 2007). Strombach, et al., (2015) additionally examined the role of the temporoparietal junction of the brain in making altruistic decisions and during social discounting as a whole. The temporoparietal junction of the brain is commonly activated when an individual is attempting to relate to or understand the perspectives of someone else (de Quervain, et al 2004; Carter, et al. 2012). It is suggested that the role of the temporoparietal junction in social discounting is crucial in order to override selfish impulses during decision making (Strombach, et al., 2015). During a discounting function when an individual is attempting to decide whether or not he or she should keep a specific amount of money, the individual must be able to work through any of the additional self-driven motivations that occur when personal rewards are factored into the equation; this ability to look past selfish motivations occurs within the temporoparietal junction. We believe that similar results will occur during our own social discounting study.

Review of existing literature regarding neural responses to decision-making in other types of discounting studies (delay, temporal) is necessary to fully understand the neural responses that occur during decision-making in social discounting studies. In a study completed that compared neural activity during delay discounting to neural activity during social discounting (Hill, et al., 2017), it was found that neural activity during either discounting study covaried and activated a widespread pattern of neural activity including the medial prefrontal cortex, the lateral orbitofrontal cortex, the anterior cingulate, the bilateral dorsolateral prefrontal cortex, the bilateral middle temporal gyrus, the ventral striatum, and the anterior insula. In this study, it was found that delay discounting and social discounting overlap and engage very similar shared patterns of neural activity; little was revealed to suggest that delay discounting and social discounting are dissociable (Hill, et al., 2017).

1.3. Altruism, Relatedness, and Kin-selection

According to Krebs & Davies (1993), altruism is biologically defined as "acting to increase another individual's lifetime number of offspring at a cost to one's own survival and reproduction" (Jones & Rachlin, 2008). Altruism and relatedness generally go hand in hand per Hamilton's (1964) kin-selection theory which explains that although individuals may act in an altruistic, pro-social manner, altruistic behavior is dependent on the probability that both the giver and the receiver of the generous act share a gene (Hamilton, 1964; Jones & Rachlin, 2008). The greater the chances of the giver and the receiver having an identical copy of a gene, the greater the chances are that the giver will act altruistically. Relatedness is not the sole determining factor for how generous an individual chooses to be. In fact, as expressed by Jones and Rachlin (2008), an individual's choice to be altruistic may directly depend on perceived social distance and indirectly on relationships that have genetic similarities (Jones & Rachlin, 2008). Additionally, it has been determined that once social closeness has been established, individuals will be no more altruistic toward someone who is of their kin than toward someone who is not of their kin when the two fall at the same social distance (Jones & Rachlin, 2008). Similarly, Jones and Rachlin (2008) discovered that relatives at closer social distances received more money than subjects at further social distances, meaning that if an individual who was not related at all to the participant in the subject was perceived to be at a closer social distance than a distant relative, the non-related individual would receive more money than the relative (Jones & Rachlin, 2008).

In our study, we aim to examine any differences in altruistic behavior in social discounting between young people and old people by separating our participant pool into two separate groups, old and young. Present in existing literature is growing evidence that suggest that generosity increases as individuals grow older (Bekkers, 2010; McAdams, et. al., 1993, Pornpattananangkul, et. al. 2019). As people age, they tend to be more concerned with external factors such as the need to volunteer and the need to become more environmentally cautious (Cornwell, et.al., 2008; Freund & Blanchard-Fields, 2014; Pornpattananangkul, et. al. 2019). In previously conducted discounting studies involving delay or temporal discounting, elderly participants were more likely than young adults to give more money to others and donate more money to charity (Engel, 2011; Matsumonto, et. al. 2016, Freund & Blanchard Fields, 2014; Midlarsky & Hannah, 1989; Sze et. al, 2012, Pornpattananangkul, et. al. 2019). In an fMRI study involving older adults, activity in the reward centers of the brain such as the nucleus accumbens and caudate that generally enhance when participants choose to donate to charity in comparision to receiving money for themselves is especially more prominent in the older population (Hubbard, et. al., 2016). In a social discounting study completed by Pornpattananangkul, et al (2019), it was found that older participants in the study were more likely to be generous to total strangers compared to younger participants in the same study. In our study, we will investigate whether or not how many years an older participant believes to have left to live determines how altruistic he or she is throughout the study in addition to providing fMRI imaging analysis to this topic.

2. Hypotheses and Predictions

The present experiment was conducted to examine both decision-making and neural activity in accordance with social discounting and kin vs. non-kin relationships. We will additionally view variations in our different sample populations (old and young groups) to determine whether or not age and life expectancy aids in determining how altruistic an individual may be.

Prior fMRI neuroimaging studies of discounting have found Blood Oxygen Level-Dependent (BOLD) activity in the ventral striatum and the ventromedial prefrontal cortex (Cooper, Nicole et al., 2013). We propose finding similar results in our social discounting study.

Hypothesis 1a. As perceived social distance increases, altruism will decrease. We believe the further away from an individual that our participant perceives him or her self to be, the less likely our participant will be in choosing to give larger sums of money to that individual. For instance, if a participant perceives his or her mother to be socially closer (lower in social distance) than his or her friend of the same sex, our participant will be more likely to give the pre-determined sum of money to his or her mother.

Hypothesis 2a. An individual's life expectancy will be correlated with altruistic decision-making. In this instance, we predict that participants in our "old" age group (over 50 years of age) with a low life expectancy will be more likely than participants in our "young" age group (between the ages of 18-35) to make altruistic decisions. This prediction aligns with the Kin Selection Theory (Hamilton, 1964).

Hypothesis 3a. Brain activity between giving a gift and receiving a gift will be dissociable. We predict that the Ventral striatum and ventromedial prefrontal cortex should only be active when giving money or gifts to others and thus forgoing self-gratification. We also predict that in regards to altruistic behavior, the mesolimbic reward system should be activated when both giving and receiving a gift is occurring. Additionally, the extent of the reward system activity should be associated with the perceived closeness (or social distance) of the individual to our participant.

Table 1
Present study dependent variable definitions.

Dependent Variable	Definition
Social Distance	In terms of social discounting, dependent upon an idea of perceived closeness to another individual (Ex: Mother would be at a closer social distance than stranger). Ranked 1-16 for the purposes of our study.
Altruism	An individual's willingness to act in a way that benefits another person, even if it results in a personal disadvantage for him or herself. (In the current study, this would involve our participant choosing to give the specified amount of money to the individual in question instead of keeping it for him or herself.)
Generosity	The opposite of self-gratification. A subject's willingness to give a pre-determined amount of money to the individual in question.
Dissociable	Able to be separated or distinguished.
Self-gratification	The indulgence or satisfaction of one's own desires (in our study, an instance of self-gratification would be one in which our participant chose to keep the money/gift for him or herself)
Remaining Years to Live	Found by subtracting self-report age from self-reported life expectancy (Example: 95 – 70 = 25 remaining years to live)
Crossover Dollar Amount	The point in which our participant made the decision to change from giving a specified hypothetical dollar amount and forgoing self-gratification to keeping the specified amount of money and indulging in self-gratification.

Table 2
Present study independent variable definitions.

Independent Variable	Definition
Age	A self-reported account of years lived/current age given by the participant. This variable is separated into two groups: Old (50+) and Young (18-35).
Perceived Social Closeness	A self-reported account of how close a participant feels to the individual in question.
Life Expectancy	A self-reported account of years the participant believes that he or she will live until.

The above tables (1 and 2) feature a breakdown of the dependent and independent variables and their respective definitions. These variables will be utilized to analyze the data in our study and will be referred to throughout the methods section and the results section of the text. For a breakdown of neuroimaging terminology, refer to Appendix A found after the discussion and conclusions section of the report. This terminology will be referenced during the results section highlighting the fMRI data analysis.

3. Method

3.1 Participants

Participants in the study were separated into two age groups – young (18-35 years of age), and old (50+ years of age). For the initial study, three males and eleven females were classified in the "young" age category between the ages of eighteen and thirty-four with a mean age of twenty-six years. There were seven males and four females between the ages of fifty-one and seventy-four with a mean age of sixty-three in the "old" age category. Participants were interviewed in a private room in the University of South Dakota Lee Medical School where they were taken through the informed consent process. The participants then filled out a questionnaire evaluated to determine eligibility for the fMRI scan. After determining eligibility and completing the study, participants received $40 USD as compensation for travel expenses to and from the scanning location in Yankton, SD.

3.2 Procedure

3.2.1 Screening and Social Distance. Participants completed the informed consent process in addition to compiling demographic information and an MRI screening to determine whether or not they would be eligible to participate in the fMRI research study. After being deemed eligible for the study, participants each completed a pre-scan evaluation. During these evaluations, our participants were asked to rank individuals one through sixteen based upon perceived closeness to those individuals with one being closest and sixteen being the furthest. The individuals each participant ranked include: neighbor, brother/sister, daughter/son, first cousin, closest friend of the same sex, teacher, nephew/niece, closest friend of different sex, mother/father, stranger in need, grandchild, grandparent, spouse/significant other, stranger randomly chosen from the world, aunt/uncle, co-worker, and foreign person met on a tour. Participants were asked to rank all listed individuals, even those that were hypothetical; our participants would eventually be given the option to indicate which relationships were hypothetical at a different phase in the study. In the following phase of the pre-scan questionnaire, participants were given the same list of individuals and were asked to imagine themselves on a “vast field” with all sixteen of the individuals in which they were asked to give a numerical value to the estimated distance between the participant and the individual. There were no limitations on how close or far each individual could be listed other than that the numerical value was to be listed in feet.

3.2.2 Functional Imaging Data Collection. Functional imaging data were collected via fMRI testing in Yankton, SD at the Avera Sacred Heart Hospital during the hours of 9:00 AM and 5:00 PM. During the fMRI scanning phase of the study, participants were asked a series of questions in relationship to the way they ranked the individuals in the pre-scan evaluation form that determined perceived closeness. First, the participants were asked to imagine various instances in relationship to gift giving including: imagining receiving a gift valued at $100 that they really wanted, imagining a person who has a certain relationship to them (half mentioned were kin and half were non-kin), imagining how the person displayed would feel receiving a gift from the participant, and imagining how the participant would personally feel giving a gift to the mentioned individual.

3.2.3 Social Discounting and Gift Giving Data Collection. Next, the participant was asked to make a series of eight judgments based upon preferences regarding giving, receiving, or keeping a specific amount of money, comparable to the questions asked in the gift-giving phase of the scan. The second set of questions were prompted based on the individuals that the participant ranked first, second, fifth, tenth, and fifteenth in the initial pre-scan questionnaire in relation to perceived closeness. For instance, a participant would only be asked a question in this phase of the experiment about their mother or father if the participant ranked that individual as one, two, five, ten, or fifteen in the initial questionnaire.

3.3 Setup

Participants lay supine inside the scanner with their head stabilized to prevent and reduce any unnecessary head movement. At the head of the fMRI scanner, a compatible 30" LCD screen (Invivo, Gainesville, FL) was placed in addition to a rearward facing single reflection mirror box attached to the top of the head-coil to ensure the participants were able to read the protocol. An fMRI-compatible button response box (Lumina LP-400, Cedrus Corporation, San Pedro, CA) was used to collect participant responses to the behavioral stimuli. This button response box was placed at the participant's midline falling right below the chest to ensure comfort of the participant and to prevent and eliminate unnecessary movement throughout the course of the experiment. The button box was strapped to the participant's wrist via a Velcro strap during the experiment, ensuring that the response box would not move during the experimental scans. The stimulus presentation and the collection of the behavioral data were completed with the use of a dedicated PC running custom LabVIEW software (LabVIEW 2012, National Instruments, Austin, TX).

3.4 Scanning Sequence

To collect data, typical Blood Oxygen Level Dependnet (BOLD) imagining techniques were used on a 3-Tesla Whole-Body Siemens Skyra scanner and integrated 32-channel birdcage RF coil (Siemens, Erlangen, Germany). FMRI volumes were collected using a T2*-weighted, single-shot, gradient-echo, echo-planar imaging acquisition sequence. Acquisition was angled along the plane of the anterior and posterior commissures. One hundred and two (the first three functional scans were not collected to allow for an equilibration of saturation effects) volumes were collection for each functional scan run, with two volumes being collected for each trial. In total, three scan runs were collected, for a complete total of 206 volumes of the whole brain [TR, 2000 ms; slice thickness, 4 mm; in-plane resolution, 3.44 mm X 3.44 mm; matrix size, 64 X 64; FOV, 220 X 220 mm; gap thickness, 0 mm; flip angle 70°]. After functional imaging collection, a high- resolution T1-weighted Magnetization Prepared Rapid Acquistion Grade (MPRAGE) [TR, 2300 ms; TE 2.13 ms; FOV, 192 X 256 X 256 mm; .9 mm X .9375 mm X .9375 mm voxels; flip angle, 9°] was collected for each participant.

3.5 Imaging and Behavioral Data Analyses

To complete imaging analyses, Brain Voyager QX 20.6 (Brain Innovation, Maastricht, The Netherlands) was utilized. To process the data, slice scan time correction, 3D motion correction (each volume aligned to the volume of the functional scan closest to the anatomical scan), linear trend removal, and spatial smoothing in which a Gaussian kernel with a full-width at half maximum of 8 mm was applied to the collected imaging data. Both the structural and functional imaging data were rotated so that the axial plane passed through the anterior and posterior commissures and then subsequently transformed to Talairach space.

4. Results and Discussion

4.1 Behavioral Data Results

We determined a crossover value at the point at which our participant made the decision to change from giving the specified amount of money and forgoing the amount for themselves to keeping the specified amount of money. We calculated a k-value to normalize our data across monetary amounts and social distances for comparisons. The following equation (feature in Figure 1 below) was used to solve for k, where N is equal to the social ranking of the individual (1-16), v is equal to the amount of money to give, and V is equal to the amount in question to keep. To determine a participant's crossover value, the questions were ordered in descending k-value; high k-values are a reflection of someone the participant feels socially distant to in addition to the participant keeping a large sum of money for him or her self and choosing to give little money to the other person. Likewise, low k-values are a reflection of someone our participant is very close to in addition to the participant deciding to keep a small amount of money (or none at all) and giving the individual in question a large sum. As an example, the crossover point in the table (Figure 2, *Crossover Dollar Amount with descending k-Values)* featured on the following page would have a k-value of 0.8889.

Figure 1
k-Value Equation

$$v = \frac{V}{1 + kN^s}$$

The above equation is used to solve for k where N is equal to the social ranking of the individual in question (1-16), v is equal to the amount of money in question to give, and V is equal to the amount of money in question to keep.

Figure 2

Crossover Dollar Amount with Descending k-Values

k-Value	Response
16	**Keep**
4.666666667	Keep
2.4	Keep
1.428571429	Keep
0.888888889	Give
0.545454545	Give
0.307692308	Give
0.133333333	Give
0	Give

The above table displays crossover dollar amounts with K-values using the equation featured in Figure 1. K-values here are placed in descending order. Higher k-values = self-motivated behavior, lower k-values = altruistic behavior.

Figure 3

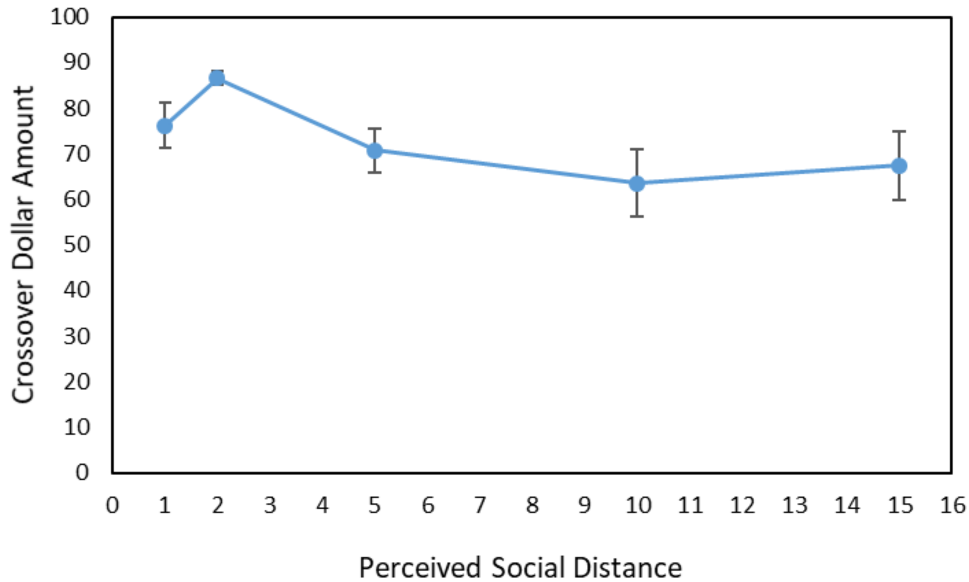
Crossover Dollar Amount and Response Illustrated

Money to Keep	Money to Give	Example Response
$5	$75	Give
$15	$75	Give
$25	$75	Give
$35	$75	Give
$45	$75	Give
$55	$75	Keep (Crossover Point)
$65	$75	Keep
$75	$75	Keep
$85	$75	Keep

Featured above is an illustration of hypothetical answers that could be given by participants during the study. Circled in red is the given crossover dollar amount for this hypothetical answer displaying the point at which our participant became self-motivated.

4.1.1. Did the crossover dollar amount differ based on perceived social distance?

Figure 4



The above figure features a breakdown of participant responses with calculated crossover dollar amount featured on the y-axis and self-reported perceived social distance featured on the x-axis.

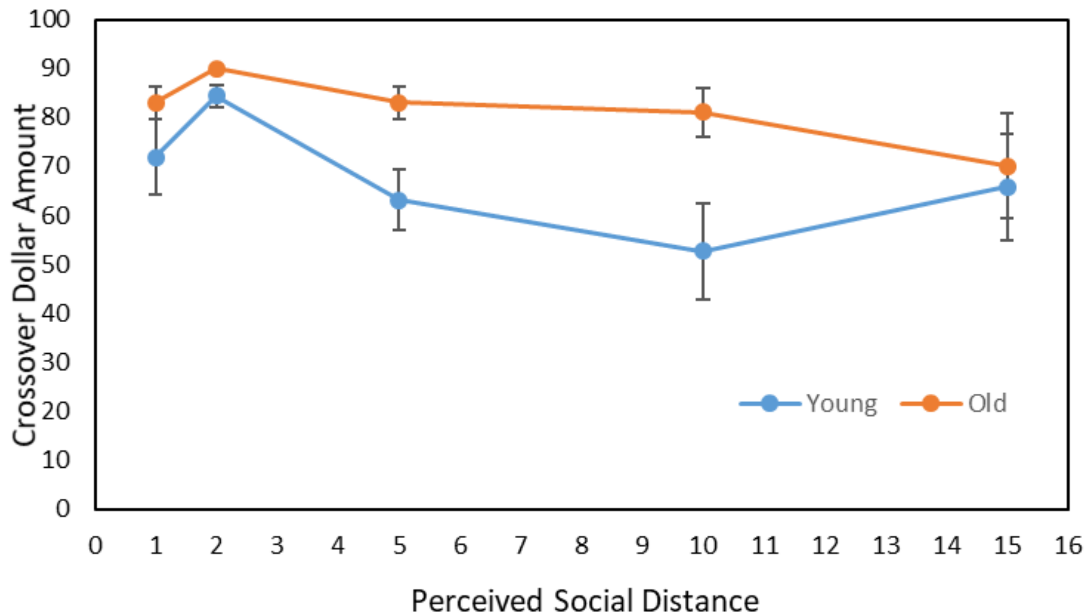
Our analysis yielded that the main effect of social distance was significant, $F(4, 48) = 3.506$, $p = .014$. We found that the dollar value at the crossover point differed depending on the gift recipient's perceived social distance, with most altruistic behavior associated with those ranked at a social distance of 2. The results of this analysis can be found above in figure 4. Though it is interesting that our participants most commonly displayed altruistic behavior for those perceived to be second in social distance, we found that generally, our participants were choosing their significant others (or hypothetical significant others) as social distance rank number one, and their children (or hypothetical children) as social distance rank number two. This altruistic behavior towards children, or those next in line as an individual's kin, can be linked to Kin Selection Theory (Hamilton, 1964). According to existing literature, an individual's perceived closeness to another determines how altruistic they are in general more prominently than relatedness

(Jones & Rachlin, 2008), but our study suggests differently in this regard. Further investigation into this variation would be necessary in order to prove or disprove this theory.

4.1.2 Did the effect of social distance on crossover dollar amount differ between the older and younger participants?

We found that the main effect of social distance was significant for participants in our younger age group, $F(4, 28) = 2.783$, $p = .046$, but not for our older participants, $F(4, 16) = 2.186$, $p = .117$. This difference appeared to be driven by the overall generally more altruistic behaviors displayed by our older participants, aligning with findings from existing research that suggest that the older population of individuals are generally more generous, no matter the link to relatedness (Engel, 2011; Matsumonto, et. al. 2016, Freund & Blanchard Fields, 2014; Midlarsky & Hannah, 1989; Sze et. al, 2012, Pornpattananangkul, et. al. 2019). A breakdown of the analysis can be found on the following page in Figure 5.

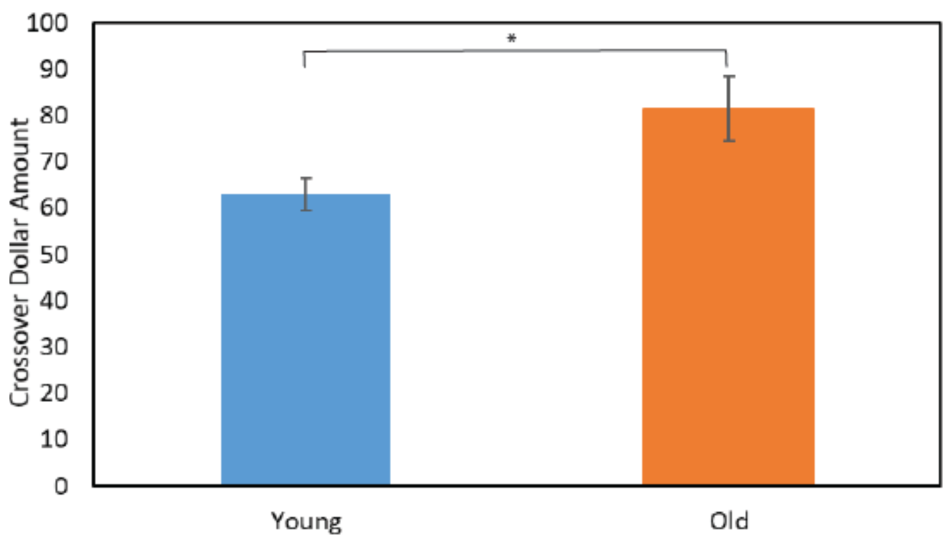
Figure 5



This figure breaks down the differences in generosity (determined by crossover dollar amount) between old and young participants.

4.1.3 Did altruistic decision-making differ between age groups?

Figure 6



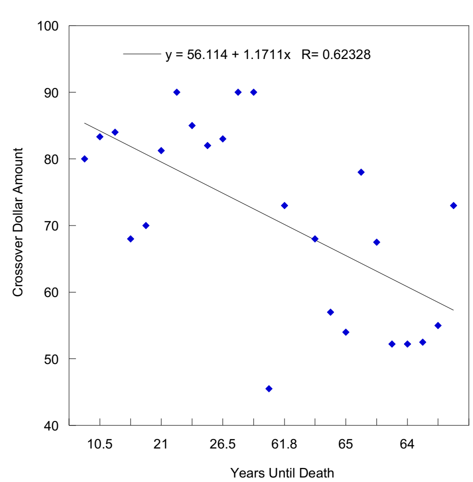
Featured above is the difference in generosity (crossover dollar amount) between age groups.

When looking at crossover dollar amount, we found that in general our older participants made altruistic decisions at a greater rate than our young participants, regardless of the social distance in question, $F(1, 23) = 18.012, p < .001$. Again, this idea of the older participants displaying altruistic decision making at a higher rate supports existing research proving similar points (Engel, 2011; Matsumonto, et. al. 2016, Freund & Blanchard Fields, 2014; Midlarsky & Hannah, 1989; Sze et. al, 2012, Pornpattananangkul, et. al. 2019).

4.1.4 Was life expectancy correlated with crossover dollar amounts?

Here, we calculated how much longer each participant interpreted that he or she had left to live from the values reported for life expectancy and current age during their initial screening by subtracting current age from reported life expectancy. We found that the number of years each participant estimated that they had left to live was significantly correlated with dollar values at the crossover point $r(24) = .618, p = .001$. The participants that displayed the most altruistic behavior were the ones who reported the shortest estimations on years left to live. A breakdown of this analysis can be found in the figure below (Figure 7).

Figure 7

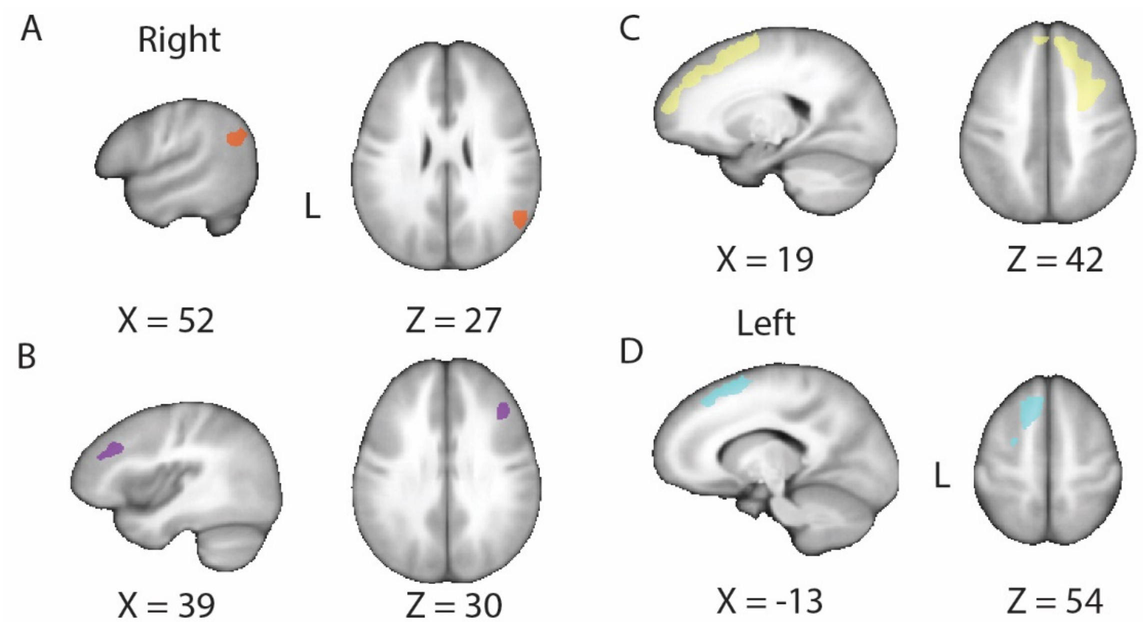


To the left is a scatterplot featuring a correlation (with outliers) between crossover dollar amount and years until death. It is clear that the fewer years our participants estimated they had to live, the more generous they were.

4.2 Neuroimaging Data Analysis

For this portion of our study, we analyzed brain activity during a second gift giving task which consisted of participants imagining themselves receiving a gift or giving a gift to those individuals that the participant initially ranked in the first, second, fifth, tenth, or fifteenth position in perceived social distance during the initial screening phase of the experiment. All analyses were performed in BrainVoyager 20.6. Examinations of brain activity showed four primary regions that were more active when participants imagined how they would feel receiving the gift in question versus imaging how they would feel giving the gift in question.

Figure 8



The clusters of activity featured here represent regions that were more active for giving the gift in question than for receiving the gift in question. Areas of increased activity were observed within the following areas: the right superior temporal gyrus (A), the right middle frontal gyrus (B), a larger cluster centered around Brodmann area 8 (BA8) (C), and the left superior frontal gyrus (D).

Figure 9

Table 1: Gift Giving > Gift Receiving						
Region	Brodmann Area	Talairach Coordinates			Number of Voxels	t
		X	Y	Z		
Areas of Increased Activity						
Cluster One—Right Superior Temporal Gyrus						
R Supramarginal Gyrus	40	54	-54	25	134	4.121
R Superior Temporal Gyrus	39	52	-58	25	570	4.643
R Middle Temporal Gyrus	39	51	-58	25	195	4.726
R Angular Gyrus	39	53	-61	30	77	4.127
Cluster Two—Right Middle Frontal Gyrus						
R Middle Frontal Gyrus	9	39	29	31	625	4.488
R Superior Frontal Gyrus	9	39	34	28	57	3.901
R Middle Frontal Gyrus	10	39	38	25	35	3.732
Cluster Three— Right BA8						
R Middle Frontal Gyrus	6	30	8	49	5078	5.851
R Superior Frontal Gyrus	6	27	6	55	2557	5.672
R Middle Frontal Gyrus	8	27	23	43	2255	5.152
R Medial Frontal Gyrus	32	23	12	43	66	4.069
R Superior Frontal Gyrus	8	21	20	50	2821	4.941
R Superior Frontal Gyrus	10	15	56	19	1766	6.093
R Medial Frontal Gyrus	10	14	56	17	393	5.596
R Middle Frontal Gyrus	10	21	56	16	236	3.914
R Cingulate Gyrus	24	23	11	43	32	4.086
R Cingulate Gyrus	32	24	9	43	118	4.421
R Precentral Gyrus	9	33	10	39	32	3.803
R Medial Frontal Gyrus	6	27	5	55	719	5.637
R Sub-gyral	8	18	28	43	71	4.217
R Middle Frontal Gyrus	9	23	39	37	37	3.644
R Superior Frontal Gyrus	9	13	56	19	2013	5.944
L Medial Frontal Gyrus	8	-6	47	41	326	5.438
L Superior Frontal Gyrus	8	-8	47	41	337	5.017
L Medial Frontal Gyrus	6	-4	47	37	105	4.881
L Superior Frontal Gyrus	9	-9	50	36	620	4.605
L Medial Frontal Gyrus	9	-6	50	37	219	5.086
L Superior Frontal Gyrus	10	-21	47	27	45	3.78
Cluster Four— Left Superior Frontal Gyrus						
L Superior Frontal Gyrus	8	-8	19	54	805	5.033
L Medial Frontal Gyrus	8	-10	32	43	111	4.843
L Superior Frontal Gyrus	6	-9	20	55	2247	5.912
L Middle Frontal Gyrus	6	-12	12	59	573	4.978
L Medial Frontal Gyrus	6	-13	9	57	229	4.216
L Sub-Gyral	6	-18	2	59	225	4.021

The above figure represents all areas of BOLD activity. Reference Appendix A found on final page for definitions of neuroimaging terminology.

The majority of activity observed in the imaging data is consistent with previous research examining altruism and charitable behaviors (Moll, J. et al., 2006; Decety J. et al., 2004).

5. Discussion and Conclusion

The importance for using social discounting as a tool to understand the implications of social distance and relatedness in generosity and gift giving widens the field to evaluate decision-making in prosocial and antisocial behavior in greater detail (Strombach, et. al., 2015). In our study, we were able to look specifically at crossover dollar amounts in relation to perceived social distance, the effect of social distance on crossover dollar amount between older and younger participant groups, whether or not age determined whether or not an individual was more or less altruistic, relevancy or life expectancy in regards to crossover dollar amounts, and neural responses to gift giving.

It is important to note that though some may be skeptical about the use of an fMRI neuroimaging scanner to collect data to be analyzed and used to further understand how humans interact because of the nature of the environment in which the data is collected, it has been continually tested and supported that the scanner environment did not affect discounting behavior substantially in comparison to studies carried out in an environment that could be considered more "normal" (Strombach, et al., 2014; Jones & Rachlin, 2006; Strombach, et al. 2015). Social discounting studies completed inside and outside of the fMRI scanner yielded similar results, thus making the results of our study valid regardless of the environment in which the data were collected.

Additionally, participants in our study were compensated equally at the end of their time in the study regardless of how they answered the questions in the scanner relating to social discounting and gift-giving. Our participants were answering questions and speculating about how they would respond knowing that their answers would not yield them a specific pay-off at the end of the study, and all participants were aware of the nature of the hypothetical rewards in which they were answering questions about. According to Rachlin and Jones (2006), there is no reason to believe that the results of any discounting experiment that uses only hypothetical money amounts in question during the study are any less valid than those utilizing real money amounts (Jones & Rachlin 2008, Johnson & Bickel, 2002).

According to Jones & Rachlin (2006), people will choose to forgo a hypothetical reward for themselves in order to provide seventy-five dollars for another person with this amount of hypothetical money being forgone varying systematically with the perceived social distance of the individual who will be receiving the seventy-five dollars. In our study, our analysis yielded similar results; the main effect of social distance was significant. Additionally, we found that the main effect of social distance was significant for younger participants, but not for older participants; our older participants were generally more altruistic in general which aligns with existing research (Engel, 2011; Matsumonto, et. al. 2016, Freund & Blanchard Fields, 2014; Midlarsky & Hannah, 1989; Sze et. al, 2012, Pornpattananangkul, et. al. 2019).

In our study we found in analyzing brain activity during a second gift giving task which asked participants to imagine themselves receiving a gift or giving a gift to an individual specified (one that the participant ranked in the initial screen phase 1st, 2nd, 5th, 10th, or 15th in social distance) that four primary regions of the brain were more active during the participant's imagination of how they would feel giving a gift than were during the imagination of receiving the same gift. These areas of increased activity include: the right superior temporal gyrus, the right middle frontal gyrus, the Brodmann area 8, and the left superior frontal gyrus.

In existing research, it has been found that generous choices engaged the temporoparietal junction in a way that supports the idea that temporoparietal junction activity promotes acts of generosity (Strombach). Strombach, et. al (2015) also found activity in the ventromedial prefrontal cortex to be significantly higher during altruistic decision making than during self-motivated decision making. The findings in our study aid in the on-going differentiating between which areas of the brain are more active when comparing altruistic and selfish decisions.

An area of distinction between our study and existing research lies within our idea of creating a “remaining years to live” variable by subtracting current reported age at the time of the study from reported life expectancy and relating that variable to overall altruistic behavior. In our study, we found that individuals who were the most altruistic in their decision making habits were those who reported the shortest estimations on remaining years to live. Thus, it can be determined that individuals who perceive themselves to be closer to death are generally more altruistic in their decision-making practices, especially in relation to money; the number of years each participant estimated to have left to live was significantly correlated with dollar values at the crossover point. It is important to note that those individuals in our study who reported fewer years remaining before death were not more altruistic to individuals solely of their kin, they were altruistic in each aspect of their decision making.

One potential way to expand the scope of our study is to separate our data for an analysis based on gender. It may be interesting to look at the differences of our entire subject population between males and females, but progressing even further into our two age categories, a breakdown by gender in both our old and young participants could add an additional element of understanding to neural and behavioral responses to self-motivated and altruistic decision-making. Existing research on the topic of gender differences in response to social discounting is sparse, but there is a large body of evidence that suggests that women are generally more prosocial than men (Croson & Gneezy, 2009; Rand, et al., 2016; Rand, 2017, Soutschek, et al., 2017). It is suggested in a study by Soutschek, et al. (2017) that brain activity specifically in the striatum was more pronounced for prosocial behavioral in women and selfish behavior in men, while a whole brain analysis showed no further gender differences in any other brain region (Soutschek, et al, 2017). In terms of expanding our study, it may be interesting to determine whether or not these differences are consistent no matter the age of the participants. Strombach, et al. (2016) showed that effects of overburdening cognitive load (giving the brain multiple tasks to manage at one time) forced men, but not women, to simplify their decisions during social discounting tasks. This is a factor that we could potentially take into account during our study to look at the consequences of cognative load on men in women of both old and young populations.

APPENDIX

Appendix A

Table 3

Present study neuroimaging terminology definitions.

Neuroimaging Term	Definition
Brodmann Area	Areas of the cerebral cortex of the brain separated into 52 differents areas which are defined by their histological structures and cellular organization
Talairach Coordinates (X,Y,Z)	Talairach coordinates, or space, is a three-dimensional coordinate system of the human brain, which is used as to map the location of brain structures independent from individual differences present in size and shape of each person's brain (no two brains are alike, Talairach Coordinates allows each individual brain to be analyzed in the same way).
Voxel	Small cube of brain tissue analogous to the two-dimensional computer screen pixel that acts as a three-dimensional building block representing a given slice thickness. Many voxels stack to create clusters of BOLD contrast in fMRI analysis.
fMRI	Functional Magnetic Resonance Imaging, measures brain activity associated with increased areas of blood flow.
BOLD Contrast	Blood-oxygen-level-dependent contrast, a method used in fMRI to observe different areas of the brain which are found to be active at any given time.

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