The role of fear in home-biased decision making: first insights from neuroeconomics

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ABSTRACT

We used functional magnetic resonance imaging ("fMRI") to investigate the neural mechanisms underlying home–biased, financial decision-making. Twenty-eight subjects were instructed to make binary investment decisions between a foreign and a domestic mutual fund. Differential brain activity was detected between decisions involving funds of different national origins. In situations where participants had to decide between mutual funds from different countries, we found increased activity in the precentral gyrus, the fusiform gyrus and the inferior occipital gyrus. Moreover, during home-biased decisions we found a correlation between activity within the amygdala-hippocampal regions of the brain and the investor's general risk aversion. This region has been found to be involved in negative emotional processing such as fear, so one interpretation is that home-biased financial decision making is modulated by negative emotions associated with risk aversion.

Keywords: Financial Decision-Making, Home-Bias, fMRI, Neuroeconomics

"If there is one thing that modern societies have a priori, it is fear."

Niklas Luhmann

INVESTOR DECISION-MAKING is at the core of research on financial markets. While some researchers assume that investors decide more or less rationally, others claim that investors decide irrationally and make numerous systematic errors with respect to their investments (Thaler, Shefrin, 1981; De Bondt, Thaler, 1985; Shefrin, Statman, 1985; Odean, 1998; Loewenstein, Willard, 2006). The phenomenon known as "*home-bias"* is one of these systematic errors (Lewis, 1999; Karolyi, Stulz, 2003). It describes the finding that investors allocate a sub-optimally large proportion of their wealth in domestic assets, compared to the predictions of portfolio theory. This phenomenon has been demonstrated in numerous empirical studies with the extent of the effect varying slightly between countries and years (see Table 1).

Study	Cooper/Kaplanis (1994)	French/Poterba (1991)	Coen (2001)	Faruqee et al. (2004)
Year	1987	1989	1994	1997
Germany	72,2%	n.r.	75,63%	79,33%
France	n.r.	n.r.	87,83%	57,94%
UK	68,2%	68,2%	40,72%	57,94%
Japan	43,0%	71,60%	49,96%	76,05%
Canada	n.r.	n.r.	70,71%	67,67%
Italy	89,10%	n.r.	83,36%	76,19%
USA	61,6%	46,0%	52,11%	30,25%
Mean	66,82%	61,93%	65,76%	64,57%

Table 1: Empirical Evidence of the Home-Bias Phenomenon in G7 (n.r. = not reported)

Here, we aim at investigating the neural underpinnings of home-biased decision-making, to enhance the understanding of the underlying psychological processes. The remainder of this paper is organized as follows. Section 1 gives a brief overview of why home biases occur, with a focus on selected psychological mechanisms. Section 2 describes the data and methodology in our study. In this section we give a short overview of functional magnetic resonance imaging (fMRI). In this section we also present our findings, which are then discussed in section 3. In section 4 we outline some limitations and implications of our study, and section 5 concludes.

1. PSYCHOLOGICAL CAUSES OF THE HOME-BIAS PHENOMENON

Several sophisticated approaches to investigate the home-bias effect have been suggested in the literature (Coval, Moskowitz, 1999; French, Poterba, 1991; Chan, Covrig and Ng, 2005, Cooper, Kaplanis, 1994). Roughly, these can be divided into two groups:

First, the *classical approach* assumes a rational decision-maker and attempts to explain the reasons for theoretically incorrect behavior using external market barriers or inefficiencies. Proponents of this view argue that institutional factors and transaction costs (such as monetary and regulatory investment barriers as well as inflation hedging) can lead to home-biases (French, Poterba, 1991; Kilka, Weber, 2000; Lewis, 1999). This approach is able to partially explain home-bias but seems unable to account for it entirely, as several studies have shown (Cooper, Kaplanis, 1994, Uppal, 1992).

Second, *approaches in behavioral finance* take into account the imperfection of human decision-makers and integrate them into the analysis as possible sources of errors (Thaler, Shefrin, 1981; De Bondt, Thaler, 1985; Shefrin, Statman, 1985; Odean, 1998; Shefrin 2002). Some authors suggest that perceptions of risk and reward are distorted (e.g. Schiereck, Weber, 2000; Cooper, Kaplanis, 1994). With respect to home-bias, it is possible that a greater level of *confidence* in local and more familiar markets leads to an underestimation of the risk of domestic investments and an overestimation of their returns (French, Poterba 1991). In an earlier study, Uppal (1992, p. 186) suggested that "an important factor that may inhibit international diversification is the unfamiliarity with foreign assets". Cooper and Kaplanis (1994, p. 51), argue that investors might "have some built-in prejudice against foreign investments". If an attempted portfolio optimization is conducted on the basis of such distorted perceptions or prejudgments, it might then seem rational to invest a high proportion of one's capital in domestic assets.

The distorted perception of risk and rewards is often also accompanied by the phenomenon of *overconfidence* (Camerer, Lovallo, 1999; Daniel, Hirshleifer, Subrahmanyam, 2001). It describes the tendency of investors to overestimate their own knowledge of the risks and returns associated with various investments. This leads to a declining tendency to inform oneself about "real" values which increases the probability that portfolios will be constructed based on distorted risk and return expectations. This phenomenon of overconfidence is particularly conspicuous with respect to domestic investments which seem more familiar to investors. In short, distorted perceptions of risk and return exacerbated by overconfidence and the associated tendency to misinform oneself about the real value of investments, are possible explanations of the home-bias effect.

Another possible explanation is that a lack of experience combined with the risk of losing a proportion of one's wealth, leads to risk-aversion-induced *fear* of foreign investments. As French and Poterba (1991) highlight, fear may impute extra "risk" to foreign investments because potential investors know less about foreign markets, institutions, and firms. In that sense, the tendency to trust domestic products and investments more than those from other countries can be thought of as a heuristic to reduce fear. If one accepts this explanation, fear might be a relevant variable in the home-bias puzzle. Many private investors that we interviewed stressed that the fear of losing money has a major impact on their investment decisions. Avoiding foreign investments may help assuage these fears (Coval, Moskowitz, 1999, p. 2046).

2. EMPIRICAL STUDY

A. Theoretical and methodological considerations

The dangers and threats that confront an individual are always subject to change. An adaptive behavior therefore requires an ability to learn about both harmful and rewarding stimuli. This *emotional learning* has been studied in neuroscience, where the most significant progress has been in determining the underlying neural circuitry in fear conditioning (LeDoux, 1996). Recently there has been more research-interest in the role of fear in financial decision-making (Lo, Repin, Steenbarger, 2005; Shefrin 2002). One complication is that unlike risk, which is an objective measure, it is difficult to measure fear, for the following reasons:

1. In many cases, fear is socially undesirable. Consequently, in surveys, people sometimes deny experiencing fear in particular situations.
2. Because of its emotional character, fear is often subconscious and difficult to articulate.
3. Fear can manifest itself suddenly and be present only fleetingly. Therefore, to be valid, the significance of fear for financial decision-making should be measured temporally close to its occurrence.

As a result, if one wanted to measure the influence of fear on financial decision-making, the first issue to deal with would be the appropriate method of measuring fear. Given the difficulties mentioned above, it seems necessary to use a valid and reliable measurement-tool in order to ensure a comprehensive and complete description of the relevant decision-making processes. One such tool could be fMRI of the brain, which has recently been used in the context of economic research (Camerer, Loewenstein, Prelec 2004; Glimcher, Rusticini, 2004; Zak, 2004; Kuhnen and Knutson, 2005; Kenning and Plassmann, 2006; Huesing et al. 2006, Singer and Fehr, 2006). Moreover, research on fear has recently been based almost exclusively on “objective data”, that is, using data generated through psychological and psychiatric tests or through tests of brain physiology (Egbert/Bergmann, 2004, p. 2). In the neuroscience literature there is a bulk of evidence that feelings of fear are accompanied by increased activity in the amygdala (e.g. Buechel et al. 1998, Calder et al. 2001). Against this background, we hypothesize that home-biased financial decisions might correlate with neural activity within the amygdala.

B. Pre-study and subject recruiting

In order to test the above mentioned hypothesis, we conducted a three-staged experiment. The first stage consisted of a survey to screen the respondents based on their level of financial experience. Furthermore we collected data about the subjects' general risk-aversion (Donthu and Gilliland 1996, see appendix).

31 subjects participated in the study. Three subjects had to be excluded due to motion-artifacts or pathological findings. Of the remaining 28 subjects, 17 were male and 11 female (mean age: 26.28 years). All subjcets were informed as to the nature of the experiment and gave their written consent to participate.

C. FMRI Study

We employed functional magnetic resonance imaging (fMRI) (more precisely "BOLD-fMRI") to measure brain activity associated with financial decision-making (for a methodological overview, see e.g. Huettel, Song and McCarthy 2004, Thulborn et al. 1982, Turner et al. 1991, Kwong et al. 1992, Ogawa et al. 1992, Moseley, de Crespigny and Spielman 1996).

Image presentation. Stimulus projection was controlled using the neuropsychological stimulation software "Presentation". To avoid confounding factors in stimuli recognition, we carefully selected stimulus objects of equal size and displayed them in identical positions, against the same background, and with the same level of brightness, for all trials (for an example see Figure 1). Every 6 seconds a pair of different mutual funds was projected. In accordance with the objectives of the experiment, a differentiation was made between different pairs of stimuli: Domestic-Foreign ("DF"), Foreign-Foreign ("FF") and Domestic-Domestic ("DD"). In DF trials, subjects were presented with a particular brand logo for one domestic and one foreign mutual fund. In FF and DD trials, subjects were presented with brand logos for two foreign or domestic (German) funds, respectively.

Figure 1: Example for Choice Task

The stimuli were presented using a block design, which has the advantage of a greater level of statistical power, compared to an event-related design (Buckner, 2003; Dale, 1999; Friston et al., 1999) (see Figure 2). Each block was comprised of five trials, four of which were of the same time type, and the fifth one served as a dummy (what does “dummy” mean?). Twelve DF, six FF, and six DD blocks were used. In total, 48 DF, 24 DD, and 24 FF decisions had to be made. The subjects recorded their choices using a simple button-response box.

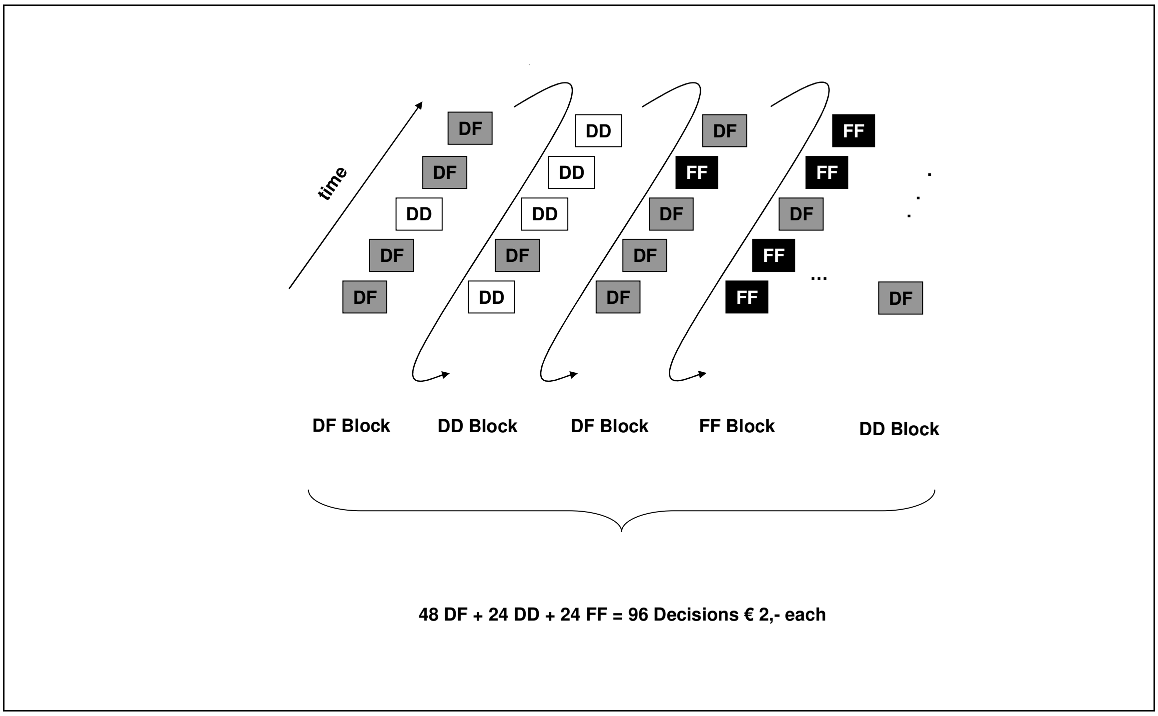

Figure 2: Experimental Design

Participant instructions and preparation. Before scanning, the participants were screened for physical and mental disorders. All participants gave their informed consent to participate in the study and the University’s Medical School ethics committee approved the experiment. Before entering the scanner, the participants received a verbal description of the task. They were instructed that after the acquisition of structural images, functional images would be taken, and their participation would be required. Before starting the experiment, the respondents were informed about the experimental procedure. They were informed that they would need to decide on one of two investment opportunities by means of the response box. They were asked to consider the following question: "in which of the two mutual funds would you invest your money?" Care was taken to ensure that each participant received the instructions in the same way and that they understood the task completely. To avoid confounding factors, the trials were designed to be as close as possible to real financial decision-making situations. Therefore the respondents were faced with gaining or losing real money, based on their financial decisions. A total of € 192.00 was available to each of the subjects, which they could invest as they wished in the presented alternatives. Accordingly, at the end of the investigation, the subjects received returns that depended on the actual mutual fund performances. More precisely, the rate of return over the past six months for each investment was paid out to the subjects.

Subjects were placed in the scanner and asked to avoid head movements. Foam pads and a soft headband were used to facilitate head-fixation. Earplugs and a headset were employed together to protect against scanner noise and to allow for communication with the participant (e.g. to announce the beginning of the experiment after finishing the preceding structural measurements).

Acquisition of functional MR images. Imaging was performed using a Siemens 3.0 T head scanner (ALLEGRA) (TR/TE 1700/35, 26 slices, slice thickness 4+1mm, 64x64 matrix, field of View 192mm, 247 Volumes per session).

fMRI analysis. The data were analyzed using Statistical Parametric Mapping (SPM2; Wellcome Department of Cognitive Neurology, London, UK; http://www. fil.ion.ucl.ac.uk/spm, Friston 2004b; Friston 2004a; Friston et al. 1995). The data were preprocessed to correct for head movements and to allow individual data sets to be entered into group analyses. Slice timing was applied to adjust for time differences resulting from multislice image acquisition. Motion correction to the first volume was performed using a six-parameter affine rigid-body transformation. Images were spatially smoothed with an 8mm isotropic Gaussian kernel (8mm, FWHM). The hemodynamic responses without temporal derivatives were modeled in the statistical design. Preprocessed data were first analyzed at the individual level. Three regressors-of-interest (DD, FF, and DF) and 6 regressors-of-no-interest (realignment parameters) were modeled in the general linear model (GLM). For the main effect, a t-test for the contrast DF>DD+FF was calculated for every voxel. The individual contrast images were then used in a random-effects analysis at the group level. To verify our hypotheses, a correlation analysis was performed, identifying significant correlations between individual risk-aversion (measured with the RISK AVERSION scale) and changes in neural activity for the contrast DF>DD+FF ($p<0.001$ uncorrected for multiple comparisons).

D. Results

D1. Behavioral Data

For each trial, subjects in the scanner were asked to invest 2 Euro in one of the available mutual funds. The overall distribution of money was 46.25% in domestic funds (SD: 18.65%) and 53.75% in “Rest-of-the-World” funds. The home-bias effect can be specified by the difference between the actual weight of domestic assets and, with respect to the international asset pricing model, the optimal weight ω* (French, Poterba, 1991). Following Cooper and Kaplanis (1994), this optimal portfolio weight should be equal to market capitalization. With respect to the Morgan Stanley Capital International ACWI Free Index (October, 2001), the German share of global market capitalization was 2.91%. Therefore we calculated a difference between actual and optimal portfolio weight of about 43.34%. This is lower than those reported by Cooper and Kaplanis (1994), which might be due to the design of our study. Since the participants receive free money, they might tend to act a little riskier than usual. However, even in our data, there is a significant home-bias (T-Value: 12,148, df: 23, $p < 0.001$)

D2. Neuroimaging Results

Main Effect. One-sample t-test over all DF>DD+FF conditions revealed significant activations in areas of the occipital lobe, particularly in the gyrus fusiformis and the left precentral region. ($p<0.001$ uncorrected, voxel level, $p<0.05$, cluster level, see Table 2)

Table II:
Results of One-Sample-T-Test
Main Effect: One-Sample-T-Test (DF > DD+ FF)
p < 0.001 uncorrected voxel-level, p < 0.05 cluster-level (= 43 voxel per cluster); BA = Brodmann AreaM x,y,z = respective coordinates in MNI space, Z = Z-value.

		BA	**x**	**Y**	**Z**	**Z**
precentral gyrus	L	4	-36	-21	57	5.21
fusiform gyrus	R	37	30	-54	-21	4.82
inferior occipital gyrus	R	18	30	-90	-12	4.82
	L		-21	-90	-15	5.8

Table 2: Results of One-Sample-T-Test

Correlation Analysis: The purpose of this analysis was to explore if subjects with higher risk-aversion show greater activations in the amygdala. To do so, we first calculated the degree of risk- aversion for each participant. In evaluating the answers to the three questions on the Risk-Aversion Scale mentioned above, a mean of 7.26 (SD: 2.42) was obtained. Then for each subject, a DF>DD+FF contrast value was measured in the relevant areas of the brain. Table 3 and Figure 3 show the overall results of this analysis, while Figure 4 depicts significantly positive correlations between the individual contrast values in the amygdala-hippocampus region, and the risk aversion scale ($r = 0.6311$, $p < 0.01$).

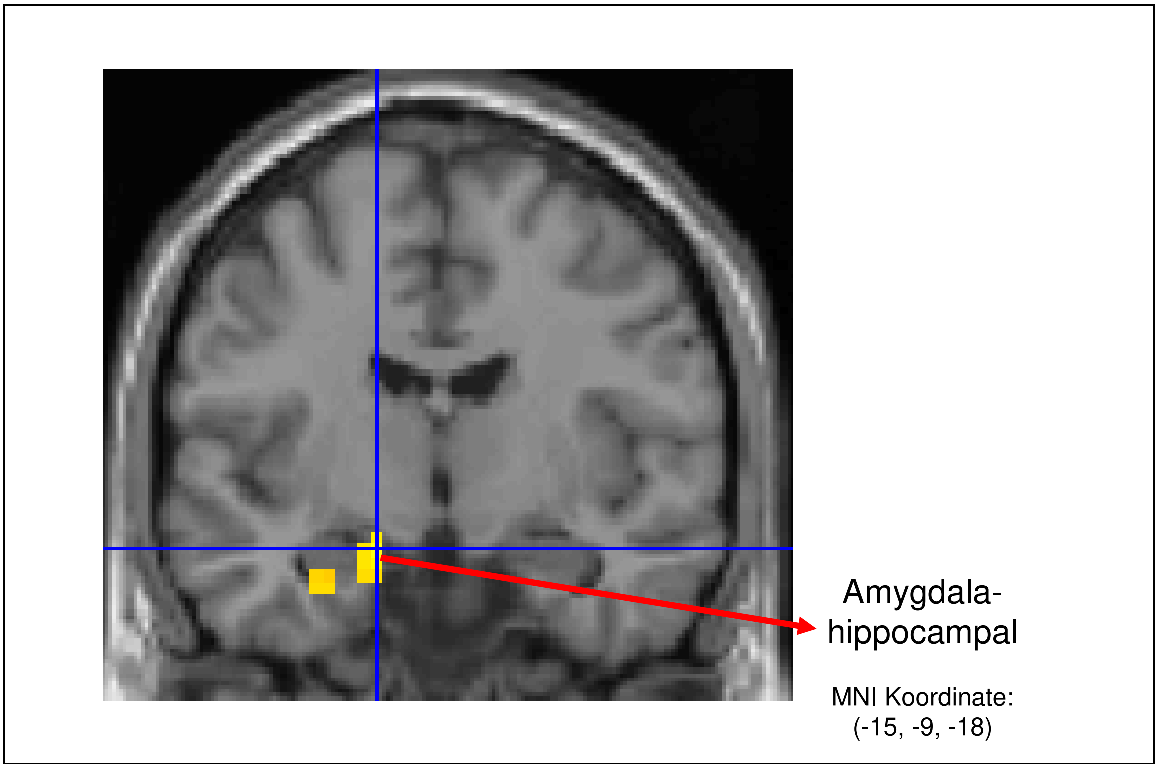

Figure 3: Significant activation in a correlation analysis between risk-aversion and individual contrast values for DF>DD+FF

Regression Analysis (DF > DD + FF and RISK)						
*p < 0.001 uncorrected voxel-level, p < 0.05 cluster-level (= 43 voxel per cluster); BA = Brodmann AreaM x,y,z = respective coordinates in MNI space, Z = Z-value; *corrected for small volume (10 mm sphere); ** in parahippo-campal cluster*						
	Side	**BA**	**x**	**y**	**z**	**Z**
amygdala-hippocampal region	L		-15	-9	-18	3.6*
parahippocampal gyrus	L	28/36	-21	-33	-21	4.27
fusiform gyrus	R	37	39	-57	-18	3.86
	L		-39	-57	-18	3.62*
inferior occipital gyrus	R	18	30	-96	-6	4.67
	L		-36	-93	-6	4.46

Table 3: Results of Regression Analysis

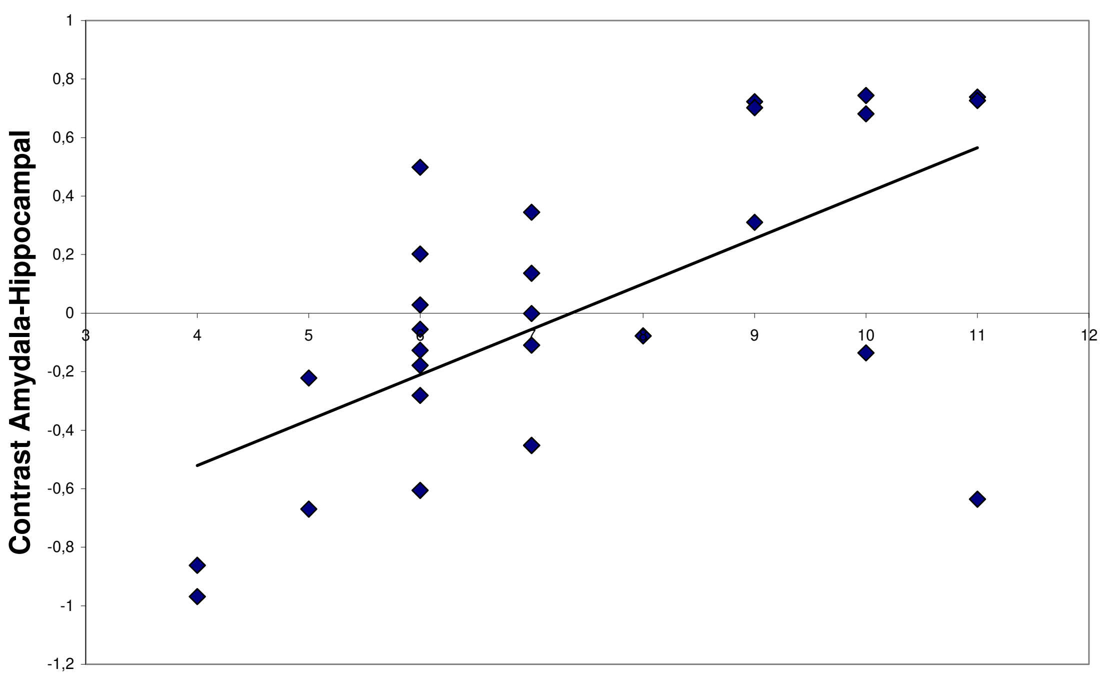

Figure 4: Correlation of risk-aversion with the contrast values of voxels within the amygdala and hippocampus (r= 0,6311)

3. Discussion

A. Main Effect

The *precentral gyrus* (BA 4) is part of the human primary motor cortex. The primary motor cortex controls directed movements of the body through nerves that pass through the brainstem and spinal cord to the muscles in the body. Moreover, the primary motor cortex (also known as M1) works in association with pre-motor areas to plan and execute movements.

The *gyrus fusiformis* is part of the temporal lobe (Vuilleumier et al. 2001, Williams 2001). It is also known as the (discontinuous) occipitotemporal gyrus. There is still some dispute over the functions of this area, but there is relative consensus that it is involved in the processing of color information and recognition of faces, words and numbers.

B. Correlation Analysis

When comparing neural activity changes in DF>DD+FF-conditions with individual scores on the Risk-Aversion Scale, we found a significant positive correlation in the inferior occipital gyrus, the parahippocampal gyrus, the fusiform gyrus and the amygdala-hippocampal region. This means that the higher the individuals scored on the Risk-Aversion Scale, the greater the activation in these regions.

The *amygdala-hippocampal* region refers to an area in the brain which includes both the amygdala and parts of the hippocampus. While the amygdala is a relatively small brain structure, the development of fMRI has allowed investigators to study brain responses in this area. Some of those studies have been successful in showing amygdala involvement in conditioned fear (Buchel, C. et al., 1998; Buchel C. et al., 1999 and LaBar et al., 1998, Olsson et al. 2005). Simultaneous activations of the amygdala and hippocampal areas have been observed in various neuroscientific studies, including those on *conditioned learning* (Büchel et al., 1999; Cahill, McGaugh, 1998). Interestingly, the findings of Olsson et al. (2005) show that negative racial stereotyping is accompanied by activity changes in the amygdala as well.

Occasionally, simultaneous activations of the amygdala and the hippocampus have been observed in connection with semantic memory and the knowledge system (O'Driscoll et al., 2001; Markowitsch, 2004). On the other hand, activations in the amygdala-hippocampal region have been observed in the retrieval of *emotional memories* (Maratos et al., 2001; Phelps et al., 2001; Smith et al., 2006). This term often refers to memories associated with negative emotions such as fear and anxiety. In a meta-analysis, Phan (2002) was able to demonstrate that activations of the amygdala could be observed most frequently in studies of fear. Other researchers believe that in some cases, the amygdala is associated with arousal (for a review see: Calder, Lawrence and Young, 2001 and Williams, 2001). While fear is often associated with arousal, Williams et al (2001) tried to distinguish fear and arousal by employing fMRI and skin conductance response (SCR). Their results suggest distinct roles for the amygdala and hippocampal networks. While amygdala-medial frontal activity was observed only in response to arousal, the hippocampal-lateral frontal activity occurred only in the absence of arousal.

With respect to financial decision-making, Hsu et al. (2005) reported amygdala activation correlated with ambiguity-aversion. Although not explicitly stated by the authors, it is possible that greater ambiguity-aversion is associated with a higher degree of arousal, generated by the fear of losing money. Yacubian et al. (2006) demonstrated that there are dissociable systems for gain- and loss related value predictions and they identified the amygdala as representing the loss-related part of expected value. With a lesion study, Shiv et al. (2005) reported that damage to the amygdala may have an impact on investment decisions. In their study, they observed the investment behavior of 19 normal subjects and 15 patients with stable, focal lesions in certain neural structures important for the integration of emotions in decision-making processes. Three of the patients had suffered damage to the amygdala. Shiv et al. (2005) found that the patients with damage to these particular neural structures appeared to decide using less emotion than subjects in the control group. Because of this, the patients were actually able to perform better on these tasks because the control group tended towards being overly cautious, and occasionally avoided gambles with positive expected returns. With the use of SCR in a context similar to our study, Lo, Repin and Steenbarger (2005) reported a high correlation between arousal and feelings of unpleasantness. Moreover, they report a strong negative correlation between unpleasantness and daily trading performance. Therefore they conclude that “one component of successful trading may be a reduced level of emotional reactivity” (p. 357). As a possible explanation for the negative impact of emotions on financial decision-making, they suggested that “given that trading is likely to involve higher brain functions (…) our results are consistent with the current neuroscientific evidence that automatic emotional responses such as fear and greed (e.g.

responses mediated by the Amygdala) often trump more controlled or “higher-level” responses…”. Our study seems to lend support to this suggestion.

4. Limitations, Implications And Further Research

Our study has limitations. First of all, we create a laboratory environment which may confound our results. Moreover, people were given money for investment, rather than having to spend their own. This is in contrast to real life, where people have to work to acquire money. Third, at the methodological level, it would be helpful to confirm these results with a similar experiment using other neuroimaging techniques. In particular, the application of magnetic encephalography (MEG), due to the better temporal resolution in comparison to fMRI, could provide some insight into when exactly (and with what intensity) fear impacts decision-making processes. Fifth, we forced our subjects to decide on their investments within a few seconds. Therefore it is possible that they would be less likely to decide based on gut reactions if they had time to make more cognitive, deliberate decisions. However, assuming applicability of our results, we add some useful implications, as follows.

From a practical perspective, the question arises of what people can do to reduce the influence of emotions on financial decision-making. One solution might be to delegate financial decisions to professional institutions and/or agents, such as managers of mutual funds (French, Poterba, 1991). Another strategy might be to better familiarize people with foreign investments and investments in general (French, Poterba, 1991), with the use of media reports and other information sources. In addition, fictitious depots could be created in order to help investors become more familiar with the investments, without taking real risks. The positive impacts of such activities on individual investor decisions has been shown in various studies (e.g. Bernheim, Garrett, 1996; Clark et al., 2003; Lusardi, 2003). Timing may also be an important factor in fear-reducing strategies. Chan, Covrig and Ng (2005) recently showed that stock market development plays an important role in the domestic market, so timing of foreign investments might also be relevant for decreasing fear associated with foreign investment (I don't understand this sentence; unclear). Therefore, in times when stock markets are on the rise, reducing fear via conditional learning might be more promising than in times when they are on the decline.

Given the large stakes involved, investors themselves should consider to what extent they are victims of fear. Our results suggest that people who are more risk-averse are also more fearful or emotional in home-biased decisions. But how does this risk aversion manifest itself? One indicator might be a person's level of education. A study by Riley and Chow (1992) found a negative relation between general risk-aversion and individual level of education. However, because education is positively correlated with income, this relation could also be attributed to differing levels of wealth of the respondents. In other words, people who have a small budget, might have a subjectively larger fear of incurring losses and thus might behave in a more risk-averse manner. Therefore, level of education might be a covariate of home bias. Another indicator of one's susceptibility to home- bias might be the individual degree of exposure to other cultures, since such exposure could create positive associations with financial investments in those countries. As a result, it could be that negative associations can be combated through positive exposure to other countries. Hopefully future research will find other ways to diminish the fear-related emotional response to investments from other countries as well.

5. CONCLUSION

The goal of our study was to explore the underlying neural mechanisms of financial decision making. With the aid of fMRI, we found that when subjects were deciding between domestic and foreign investments, particular brain areas were significantly activated more than in trials where they were deciding between geographically identical investments. These brain regions are the precentral gyrus, the fusiform gyrus and the inferior occipital gyrus. In geographically non-identical ("home-biased") decisions we found a correlation between the degree of individual risk-aversion and activity in the amygdala-hippocampal regions of the brain. In the neuroscience literature this region is associated (among other things) with fear processing, and so we assert that fear might have an influence on (home-biased) financial decision-making. Because risk-aversion and fear are personality attributes of the investors, and given that personality is a relatively stable construct over time, we cannot expect that it will simply "disappear by itself" over the years. Instead, we should consider different strategies that might reduce fear-induced biases in financial decision-making.

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Appendix

Risk Aversion Scale of Donthu und Gilliland (1996)
(Cronbach α = 0.693, AVE = 62,03%)

Please answer the following questions

1 = „strongly agree“ 5 = „strongly disagree“

	1	2	3	4	5	No comment.
I would rather be safe than sorry.	☐	☐	☐	☐	☐	☐
I want to be sure before I purchase anything.	☐	☐	☐	☐	☐	☐
I avoid risky things.	☐	☐	☐	☐	☐	☐

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