ELEKTRA

"**E**nhanced **L**earning **E**xperience and **K**nowledge **Tra**nsfer"

During the course of the ELEKTRA project, four Neuroscientific studies will be performed. Of these studies, the first two studies aim to investigate the impact on encoding and recall/recognition of words presented via neutral or emotionally animated non player characters (NPC's) on a Neuronal level. To be more precise, the central research question is: Can the type of animation of an NPC influence memory performance.

Event-related fMRI allows identifying brain activity related to the recognition and encoding of events, such as words, faces, or objects. Care must be taken to present temporally discrete events to be able to unequivocally relate brain activity to the underlying memory mechanisms. FMRI and similar experiments using event-related brain potentials allow assessing the neural activity related to learning and retrieval of simple facts, while paradigms allowing the reliable neuroimaging of “insight” during learning are still lacking. This is why the current evaluation will concentrate on the former tasks.

Encoding

If events (faces, words, objects) are presented during an fMRI scanning session one by one, it is possible to analyze brain activations according to a subsequent memory test. Briefly, in such Dm [**D**ifferential neural activity based on **m**emory] analyses, single trials obtained during encoding are grouped according to whether or not the presented item was recognized (or recalled) in a subsequent memory test (for a review, see Paller and Wagner, 2002). Hippocampal activation has been associated with successful episodic memory formation in a number of previous human studies (e.g., Brewer et al., 1998; Davachi and Wagner, 2002; Schott et al., 2004), i.e. items that were later recognized were associated with a greater activation of the hippocampus (and other memory-related brain areas) during encoding compared to items that were not recognized.

Retrieval

A typical paradigm to test memory retrieval is to intermix items (e.g. words, faces or objects) that have been learned in a prior study episode with similar items that the subject has not seen or heard during the learning phase. Subjects are asked to make a simple old/new discrimination. Important contrasts for the fMRI are between (a) old (i.e. previously learned items in the preceding session) and new items (i.e. not previously presented items) and (b) between successfully recognized old items and those old items that were classified as new by the subject during the retrieval task. Besides mediotemporal structures, parts of the frontal lobe have been shown to be activated during successful memory retrieval (Düzel et al. 2003; Ranganath et al., 2004).

Study 1

For the first study 240, concrete German nouns with positive and negative affective connotation and medium frequency will be selected using the CELEX

lexical data base. Affective connotation will be assessed using published data (e.g. Kuchinke et al., in press). The study will be divided into a study and a test phase.
During the study phase 120 words will be presented with the subjects' task being to memorize these words for the subsequent memory test.
Of the 120 words 60 will be presented spoken by an animated, computer-generated, photo-realistic face with synchronized lip-movements. The words will be spoken with an affective prosody that matches the emotional valence (positive or negative) of the presented word and the expression of the face will be changed accordingly. The 60 remaining words will be presented spoken by a computer-generated face with no affective modulation with respect to prosody and facial expression.
One word will be presented every 6 seconds.
After the study phase, the necessary structural scans will be carried out that are used for alignment of functional and structural images (approx. 15 min).
Subsequent to the structural scans two memory tests will be carried out. First, while still lying in the scanner, subjects will be instructed to recall as many words from the study phase as possible and to utter these words. These responses will be recorded on tape. Second, during an additional functional imaging scan the 120 words from the study phase will be presented randomly intermixed with 120 new words and subjects have to make old / new decisions, i.e. they are instructed to press a button for words that they recognize as members of the study list ("old" response) and a different button for new words.

The fMRI data of the study phase will be analyzed according to performance in the free recall and recognition retrieval tests to delineate the DM effects. The critical comparison will be between the DM effects for words presented by the affective computer face during study and the DM effects to words presented by the non-affective face.

In addition, the fMRI data from the test phase will be analysed according to word type (i.e. studied word / presented by affective face; studied word / presented by non-affective face; new word) and recognition decision (old; new).

Predictions:

a. Words presented by the affective face will be recalled and recognized better.
b. The DM effects in the fMRI will be more pronounced for words presented by the affective face.
c. The DM effects for the words presented by the affective face will engage different brain regions because of the additional use of affective information.

Study 2

The design of study 2 is very similar to study 1. The difference will be in the encoding phase: Words will be presented either by (i) an animated photo-

realistic computer-generated face with affective prosody and expression or by (ii) a computer-generated cartoon figure.

The number of words and the general design of the study will be identical to study 1.

Predictions / aims:

a. There will be a difference between the recall and recognition rate between words presented by the affective face and words presented by the cartoon character.
b. The DM effects in the fMRI will help to decide whether the presentation of material using a photo-realistic or a cartoon character is more advantageous for learning.
c. The further development of the learning system will take this information into account.

Study 3

The aim of this study is to mimic a learning situation in a more realistic way. For this study, two fictitious historic scenarios will be created and described in detail, such that each scenario will comprise 50 single items of information (i.e. names of “historical” persons, places, events) that can be condensed into one word each.

For each scenario a fully animated version using all possibilities of the learning software will be generated. Similarly, a written description of each scenario will be created as well.

The study will be carried out in two phases. During the study phase, each subject will be exposed to one of the scenarios in its animated version and to the other scenario by reading the written description. Each scenario will be presented twice. Because of the very different format of the two scenarios and the eye- and body-movements to be expected for the animated version, brain imaging is not feasible during the encoding phase. Subjects will be divided into two groups; group A will view scenario 1 in its animated version and read about scenario 2, while group B will read about scenario 1 and watch the animated version of scenario 2. This ensures a fully counter-balanced set of materials.

The test phase will take place in the MRI scanner on the day following the study phase. During the test phase the 50 names/places/events from scenario 1 and the 50 names/places/events from scenario 2 will be presented together with 100 additional new similar items in a randomised order. The 200 words will be presented one every 6 seconds with the subjects’ task being to indicate whether an item is old (i.e. from scenario 1 and 2) or new. The subjects will be instructed to actively try to remember the scenarios to carry out the task.

A standard old/new analysis will be carried out for the MRI data with the critical comparison being between old words from scenario 1 and old words from scenario 2.

Subsequent to the scanner session, subjects will take part in a paper and pencil test. Each of the 100 words from scenarios 1 and 2 will be presented and the subjects have to give a brief description (e.g. stimulus Spurzheim; subject's response: a general who fell in love with the peasant's daughter). The responses of each individual subject will be rated into 3 categories: (1) no / wrong response, (2) poor description, (3) rich description (as in the preceding example).

The single trials from the fMRI session will be recoded according to the subject's answers in the paper and pencil test and brain activations will be contrasted for items falling into the categories 1, 2, and 3.

Predictions:

a. Information presented within the interactive scenario will be recognized (old/new decision during MRI-scan) better than information coming from the written scenario.
b. Information presented within the interactive scenario will be described in a more detailed fashion (paper and pencil test) than information coming from the written scenario.
c. Due to the richer encoding of the information presented in the interactive scenario, a more pronounced and more extended brain activation will be obtained for correctly classified old items during the MRI-test compared to the information coming from the written scenario.
d. Items leading to a richer description in the paper an pencil test are associated with a greater memory related activation during the MRI-test than items with poor or wrong descriptions.

Study 4

The aim of this study is to assess the longevity of the learning effects seen for either animated or written descriptions of the fictitious historic scenarios already used in study 3.

The same materials will be used as in study 3. This time, the subjects are exposed to either the written or the animated scenario on two subsequent days and are required to watch / read each of the scenarios three times per day.

The test phase will be carried out between 9 and 12 days later. The structure of the test phase will be identical to study 3.

Predictions:

a. Retention of information presented within the fully interactive scenario over the extended time interval will be better than retention of information coming from the written scenario.
b. Information presented within the fully interactive scenario will be described in a more detailed fashion (paper and pencil test) than

information coming from the written scenario. This difference will be more pronounced compared to study 3.

c. Due to the richer encoding of the information presented in the interactive scenario, a more pronounced and more extended brain activation will be obtained for correctly classified old items during the MRI-test compared to the information coming from the written scenario. This difference will be more pronounced compared to study 3.

d. Items leading to a richer description in the paper an pencil test are associated with a greater memory related activation during the MRI-test than items with poor or wrong descriptions.