

## **Test for Attentional Performance (Mobility Version) Version 1.0**

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*This demo version is identical with the complete version of the TAP with the exception that only the pretest can be started; it is not possible to run a test and to memorize the data. To see examples of results, data of a subject are included. Instead of the external reaction keys, the keyboard is used for the registration of reactions ("1" for key 1 and "8" for key 2).*

**PSYTEST**



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TAP is registered as a medical device class I

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# 1 Attention and Driving

It is generally agreed upon that attention has to be conceived as a multi-factorial phenomenon. Common taxonomies distinguish intensity and selectivity aspects, whereas intensity aspects are divided into alertness and sustained attention and selectivity aspects encompass focused and divided attention (van Zomeren and Brouwer, 1994). In addition, a supra-modal function, the supervisory attentional control system (Shallice, 1988) including the subaspects strategy and flexibility is assumed (Zimmermann & Leclercq, 2002). It has repeatedly been shown that these different aspects have specific and distinguishable functional neuroanatomical representations (Sturm & Willmes, 2001; Posner & Raichle, 1994; Gitelman et al., 1999) and can be selectively impaired after brain injury (Hildebrandt et al., 1999; Fimm et al., 2001, Karnath et al. 2001). Intensity aspects (e.g. alertness) are usually associated with right hemispheric and brainstem areals (Sturm et al. 1999; Sturm & Willmes 2001; Fernandez-Duque & Posner, 2001), aspects of attentional orienting are located in right parietal structures (Gitelman et al. 2002; Corbetta et al. 2000), and selective, non-spatial attentional components are associated with the anterior cingulate and dorsolateral prefrontal areals (Milham et al. 2001; Posner & Raichle 1994). The anterior cingulate was shown to be connected to inhibition or facilitation of responses, whereas the dorsolateral prefrontal cortex could be associated with general attentional control (i.e. allocation of attentional resources, divided attention, top-down control) (Kondo et al., 2004; Milham et al., 2003). In accordance to these findings, three neuronal attentional networks are postulated: The alertness, the orienting and the executive network (Fan et al., 2002; Callejas et al., 2004). Cross-sectional studies of age dependence show an increase of reaction time and the intra- and interindividual response variability with increasing age, especially in spatial and executive attentional tasks (Zimmermann & Fimm, 2002a, 2002b). This could be shown in behavioral experiments (Tsang & Shaner, 1998; Hasher et al., 1991; Hommel et al., 2004, Uttl et al., 2001) as well as functional imaging studies (Hein & Schubert, 2004; Milham et al., 2002).

Michon (1971) offered a hierarchical task analysis of the subtasks participating in driving, which was adapted for application in neuropsychology and rehabilitation by van Zomeren et al. (1987), thus allowing to draw a link between concepts of attention and driving ability. Figure 1.1 outlines the Michon concept.

**Figure 1.1:** Hierarchy of driving skills according to Michon (1971).

## Hierarchy of Driving Skills\*

Strategic	
<u>Definition:</u>	Planning decisions made prior to, the drive itself.
<u>Considerations:</u>	Route, weather, time of day, traffic, density, order of stops, condition of driver.
<u>Requirements:</u>	Judgement, insight into personal limitations, impulse control, planning skills
<u>Measures:</u>	Unknown
<u>Research:</u>	None
Tactical	
<u>Definition:</u>	Behaviours and decisions made in traffic.
<u>Considerations:</u>	Adapting speed to weather and traffic conditions; deciding when to pass another vehicle; changing speed at street crossings.
<u>Requirements:</u>	Impulse and temper control; mental flexibility; judgement; risk assessment
<u>Measures:</u>	psychometric assessment; simulated or on-road- test
<u>Research:</u>	moderate amounts
Operational	
<u>Definition:</u>	Basic driving skills required to control a vehicle, steering; accelerating/decelerating smoothly; seeing other vehicles; reacting
<u>Considerations:</u>	attention, concentration, visual scanning, visual perception, mental tracking, information processing
<u>Requirement:</u>	speed, motor speed, reaction time
<u>Measures:</u>	psychometric assessment; driving test
<u>Research:</u>	much

\* Michon, 1980

Decisions on the strategic level are usually made without time pressure and often before the actual drive. On the tactical level, preparatory actions are taken while driving with a slight time pressure. On the operational level there is a constant time pressure in perceptions and actions necessary to control a vehicle. It is this level that will be most influenced by impairments in basic attentional functions. However, the tactical level too shows links to the above outlines attentional aspects such as flexibility or supervisory control. An important feature of the model is the influence of decisions on lower levels (Brouwer, 2002). By this, impairments can be compensated by adapting the driving behaviour (e.g. driving more slowly to reduce time pressure). Furthermore, it can be expected that particular conditions where the temporary loss of attention is unpredictable and relatively frequent and where it also impairs automatic action are incompatible with driving. Even, when predictions of impairments are possible, it can additionally be assumed, that severe impairments and/or lacking tactical and strategical compensation will have an impact on driving safety (Brouwer, 2002). Consequently, Brouwer (2002) pleads for the integration of divided attention tasks that prove to have moderately strong relationships with measures of car driving into the neuropsychological assessment of fitness to drive. A thorough assessment of a subject's operational and tactical driving skills that share strong relations to attentional functions might lead, together with additional assessments in a multidisciplinary team, to an improved prediction of driving performance.

## 2 The TAP assessment of fitness to drive (TAP-M)

Since attention has many aspects that can be differentiated on the theoretical as well as the empirical level (alertness, selective non-spatial attention, visuo-spatial attention, sustained attention, divided attention, inhibition processes) it seems crucial to measure these functions in a quite thorough way in order to get enough information on the driving ability of subjects with a number of tests.

These tests should fulfil several essential criteria:

- Objectivity, Reliability, and Validity requirements should be fulfilled in regard to driving skills
- They should be especially suitable for older persons
- They should be transportable and enable mobile measurements

The “Tests for Attentional Performance (TAP)” by Zimmermann and Fimm (1997, 2002) were constructed to measure different attentional functions, a subset of which was integrated into a special version for the assessment of driving ability (TAPK, 1999) which includes the subtests

- **Acoustic Alertness** (activation and phasic alertness)
- **Divided attention** (simultaneous processing of visual and acoustic stimuli).
- **Visual Scanning** (systematic search of the visual field).
- **Go/Nogo** (response selection and inhibition).
- **Flexibility** (permanent shift of the attentional focus).

Apart from the acoustic alertness test, these proven subtests were included into TAP-M.

Furthermore, it was decided to develop and add the following tasks that focus on functions commonly known as important predictors for car driving:

- **Distractibility** (maintaining visual fixation when distracting stimuli are displayed in different positions of the visual field).
- **Active visual field** (the ability to detect and discriminate objects within the visual field).
- **Sustained Attention** (maintenance of selective attention for a longer amount of time under conditions of rather high pressure)

Additionally, the test **Alertness** (included in TAP) was integrated as a simplified condition without the warning tone condition.

Apart from that, a computerized pre-screening was developed, named **Executive Control**.

Table 2.1 summarizes the tests included in the neuropsychological test battery and outlines which of these already exist within established products such as TAP or TAP-K and which have been recently developed.

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**Table 2.1: List of TAP-M subtests**

<b>Test</b>	<b>Part of existing TAP or TAP-K</b>	<b>New developments</b>
Pre-Screening (Executive Control)		<b>X</b>
Active Visual Field		<b>X</b>
Alertness		<b>X<sup>1</sup></b>
Distractibility		<b>X</b>
Divided Attention	<b>X</b>	
Flexibility	<b>X</b>	
Go/Nogo	<b>X</b>	
Sustained Attention		<b>X</b>
Visual Scanning	<b>X</b>	

<sup>1</sup> A modified version of the original Alertness task

The new tests together with the already existing ones were integrated in a common user interface allowing the selective choice, application and analysis of each subtest. This user interface, operating instructions, and important aspects of test administration are described in chapter 3.

### **3 Description of the test battery**

#### **3.1 Languages**

The current test version is available in English, German, French, Finnish, Italian, Spanish, Swedish, Greek and Dutch.

#### **3.2 Test administration**

1. The individual tests should generally be conducted under relatively standardized conditions. There are, of course, limits to such standardization. On the one hand, each subject demands different conditions and, on the other hand, each test demands slightly different procedures.
2. One obvious source of variation in test conditions is related to the differences in the monitor used for testing. These test programs have been developed using 12.5 inch monitors (32 cm diagonal screen length) with a viewing distance of 60 cm. Variations in the size of the monitors can be compensated for by corresponding changes in the viewing distance, thereby maintaining a constant visual angle. Variations in the brightness (luminance) and contrast (difference between light and dark pixels) of different monitors could affect the results to some unknown extent. Although these factors are difficult to calibrate and standardize, care should be taken not to perform the testing in brightly illuminated rooms or with bright lights directed at the monitor.
3. The subject should be seated in a comfortable chair with armrests and the arms should be positioned so that the patient might easily press the response key or keys. The subject should be instructed to press the key in the centre front area (red dot).
4. In simple reaction time tests, the subject should be instructed to hold his or her index finger just above the response key, thereby avoiding any unnecessary movements. If the key is depressed between trials, the subject is prompted to remove his finger from the response key.
5. The general test procedures should separate the task into the pretest and the main test. The pretest is to guarantee that the subject has understood the test instruction and has the basic perception skills to do the task (e.g. Divided Attention: sound discrimination; Executive Control / Active Visual Field: Colour perception). In case there are some doubts that a subject has not completely comprehended the test procedure the pretest may be given twice. A pause can be given between pretest and main test to allow the subject to ask questions or, in cases in which the subject is easily fatigued, to rest.

#### **3.3 Response buttons**

Two external response buttons (size: 5 cm x 5cm) connected with the parallel port of the PC are used to register reaction times of the subjects. They are user-friendly, proven for more than 10 years as a part of the TAP and TAP-K and are especially suited for older people suffering from motor problems such as tremor or Parkinson's disease.

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## 3.4 Operating instructions

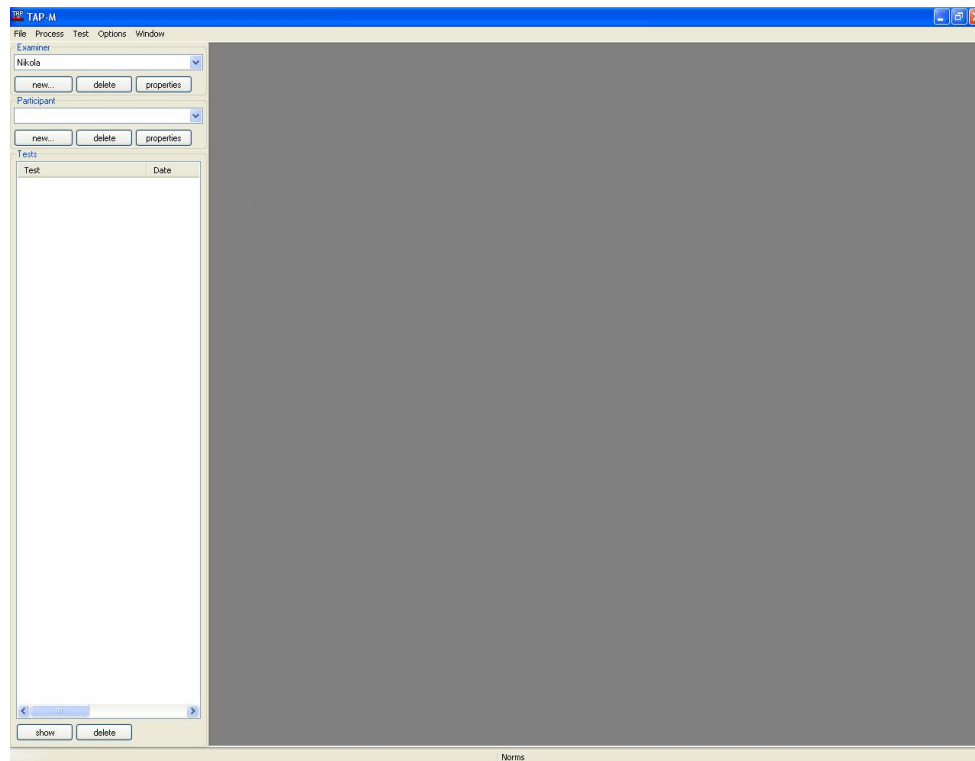
### 3.4.1 How to start TAP-M

To start TAP-M, click on the desktop icon shown below.



### 3.4.2 User interface

TAP-M presents with the following user interface:



### 3.4.3 Operation of the menu

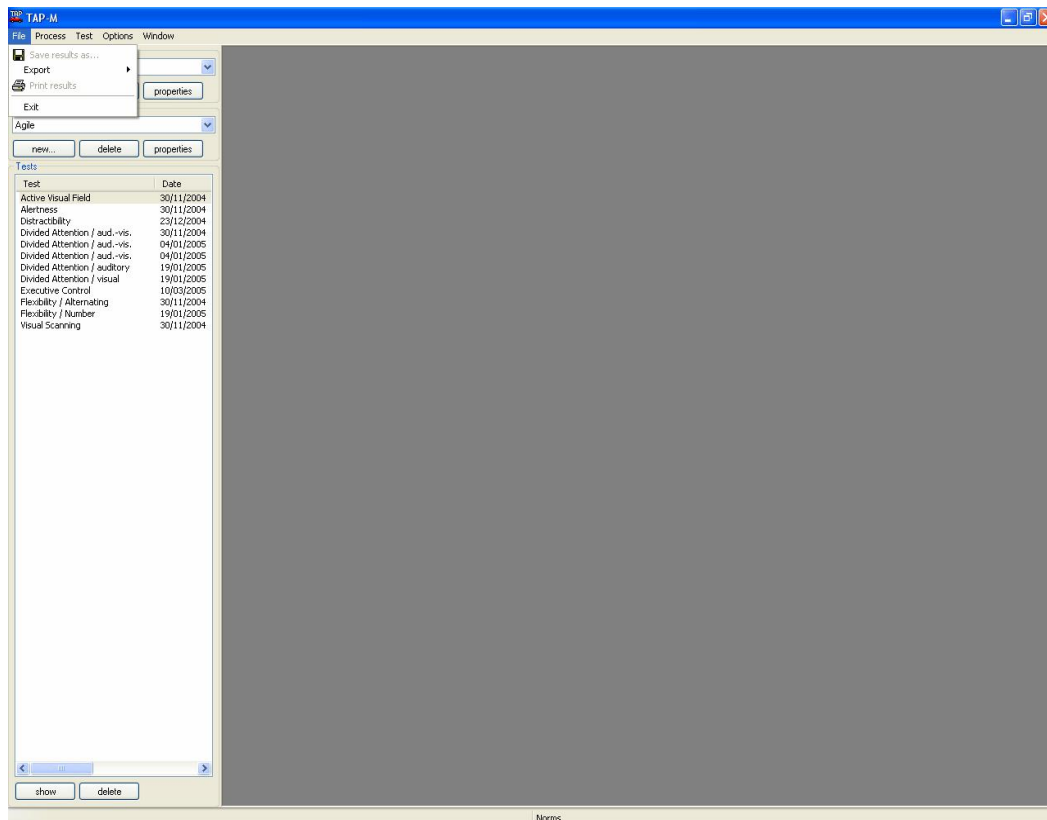
You can start one menu or one menu item either by one click on the left mouse button or by pressing “ALT” + the underlined letter (e.g. for “File” click “Alt” + “F”).

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### 3.4.4 Menus

#### 3.4.4.1 The “File” menu

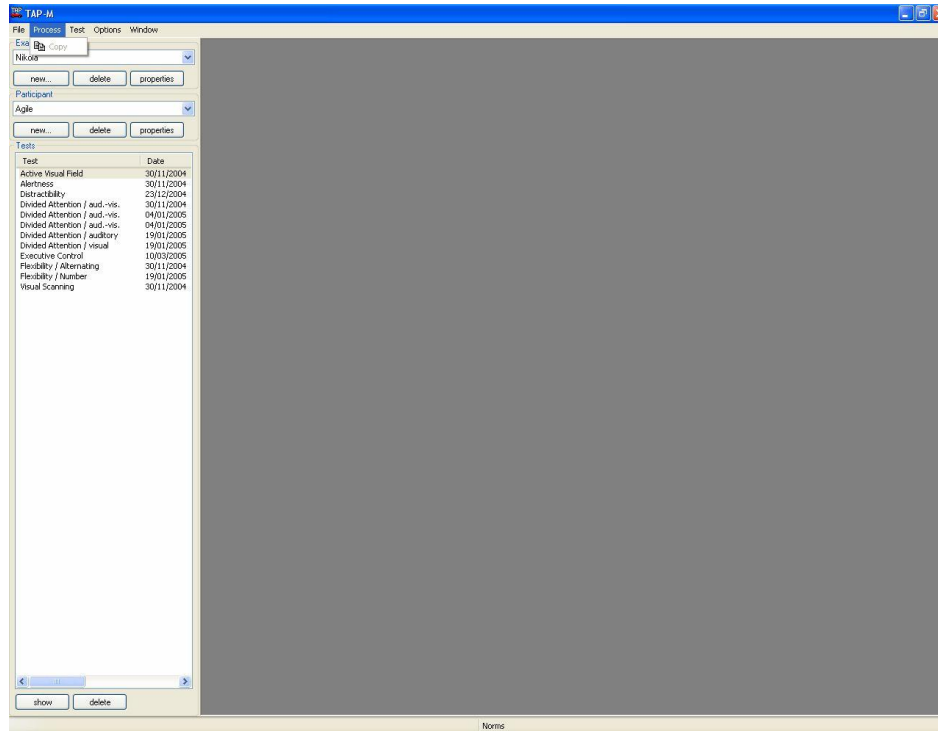
This menu offers the options “Save results as”, “Export”, “Print results”, “Printer Setup” and “Exit”.



- “*Save results as*”: With this menu item you can save the results of a subject. You only have access to this item if results are selected (see 5.1.9).
- “*Export*” opens an ASCII-file with the test results of one specific subject; these data can be imported via an SPSS - DATA LIST command into SPSS.
- “*Print results*” prints the test results. You only have access to this item if results are selected (see 5.1.9).
- “*Printer Setup*” opens a dialog box to choose the printer and to configure the print layout.
- “*Exit*” ends your TAP-M session (agenative: press “Alt”+ F4).

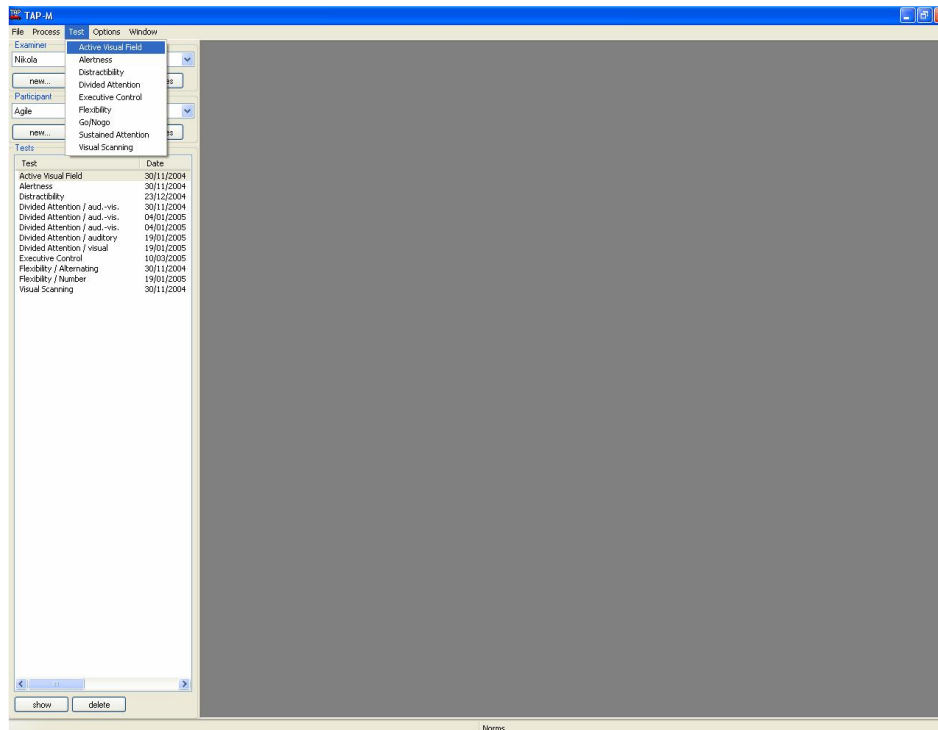
#### 3.4.4.2 The “Process” menu

This menu offers the opportunity to copy the results to the clipboard, e.g. to insert it into a Word document.



### 3.4.4.3 The “Test” menu

This menu starts the different subtests.

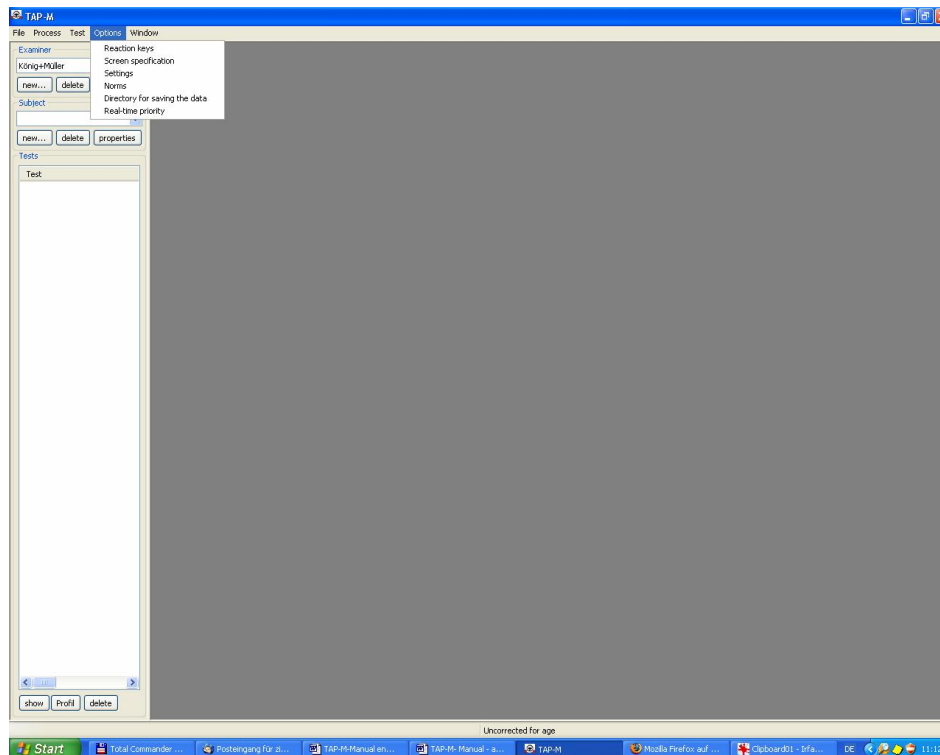


A test can be started by moving the highlighted bar with the cursor keys up or down to the respective menu item and by pressing the RETURN key or by clicking the left mouse button (see further information for testing in 2.5).

### 3.4.4.4 The “Options” menu

The “Options” menu gives access to the items “Reaction keys”, “Screen specification”, “Program environment”, “Norms”, “Settings”, “Directory for saving the data”, and “Real-time Priority”.

- “Reaction keys” specifies the parallel ports, where the response buttons are plugged in. You can choose between the ports "LPT1", "LPT2" or "LPT3". It is essential to configure this before initial testing in TAP-M. This setting is saved until the next change.
- “Screen specification” allows changing colour depth and screening resolution.



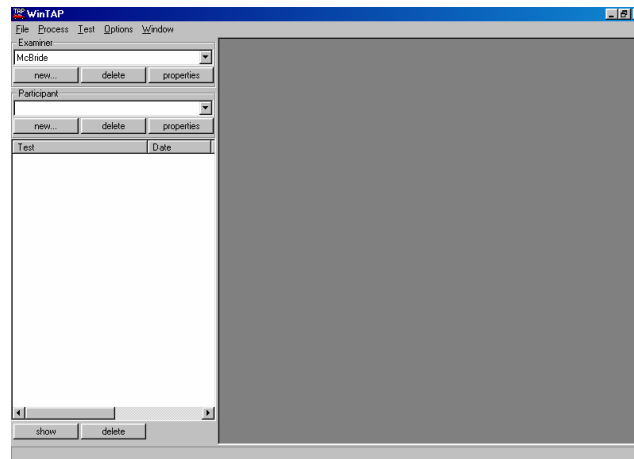
- “Settings”: You will find several options here:
  - „Selection of examiner on startup”: This option is recommended when several users work with the program on the same desktop.
  - „acoustic animation at the start of the program”: If you check this box, a short acoustic animation is played after startup of the program.
  - „Coloured graphics”: Depending on the printer you use it can be sensible to display graphics in colour or greyscale.
  - Enhanced metafiles: Should you use OpenOffice or WordPad, please uncheck this option to enable copying results files to the clipboard.
- With help of the “Norms” menu you can choose between age-corrected and uncorrected norms. For assessment of driving skills, it is often required to compare the given results of a participant with an uncorrected norm sample (see chapter 4.3.1 Computation of Norms).
- “Directory for saving data”: As a default, the directory “Personal Files” of the respective examiner is selected. It is however possible with help of this option to manually choose any other directory.
- “Real-time Priority”: We recommend to always conduct tests with real-time priority. With some systems, problems have been reported concerning tests with sound output. Should this be the case, you can run these tests in a lower priority by checking the respective option in this menu.

#### 3.4.4.5 The “Window” menu

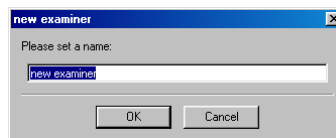
This menu offers the opportunity to bring results being displayed in multiple windows into a “cascade” order (see 5.1.9).

### 3.4.5 Specification of an examiner

TAP-M offers the possibility to create an own directory for each examiner to save his/her subjects' results. The specification of the examiner is obligatory with every access in Windows 2000, XP or NT. Before testing an examiner has to be selected or newly set.

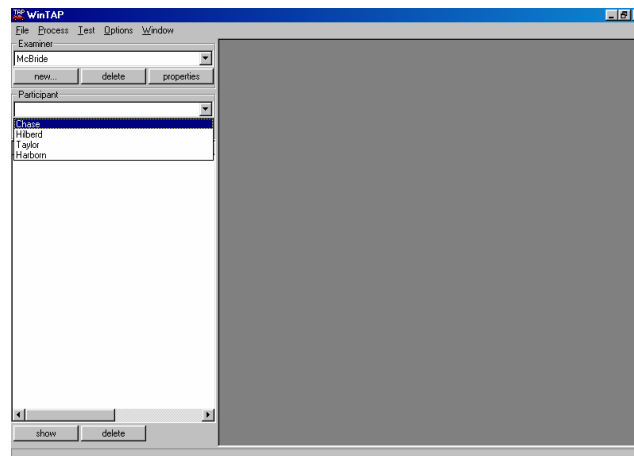


A new examiner's directory (as a subdirectory within the TAP-M folder) is activated by clicking "new" with the left mouse button. Then the window shown below is opened where you can enter the ID of the new examiner.



### 3.4.6 Specification of the participants

After examiner specification, the program requires to enter the subject's ID. If the subject was tested before by the same examiner you can choose the subject's ID from the list. (See the graphic below).





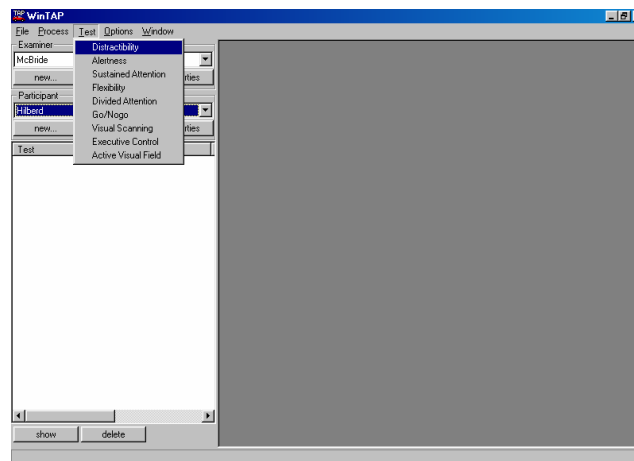
For testing a new subject click “new” with the left mouse button. Then the window shown below is opened where you can enter the ID of the new subject.

The dialog box 'Beschreibung von neuer Proband' has the following fields and options:

- Name:
- Geschlecht: ☒ männlich, ☐ weiblich
- Geburtsdatum: Calendar showing January 1970, with day 2 selected.
- Schulabschluss: ☐ Keiner, ☐ Sonderschule, ☐ Hauptschule, ☐ Mittlere Reife, ☒ Abitur
- Buttons: OK, Abbruch

### 3.4.7 Administration of a test

The “test” menu gives an overview about the different tests. A test can be selected by moving the highlighted bar to the respective item with the cursor keys “↑” or “↓” and by pressing the RETURN key or by clicking the left mouse button.



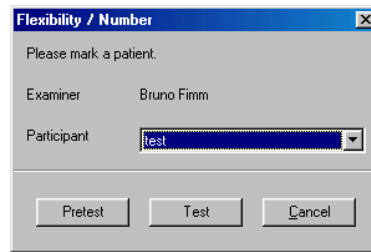
Starting a test, before a subject’s ID has been entered, leads to a window with the request “Please select subject”.

If a test with different test conditions is selected (sustained attention, flexibility and divided attention), a dialog box opens where test conditions can be chosen.

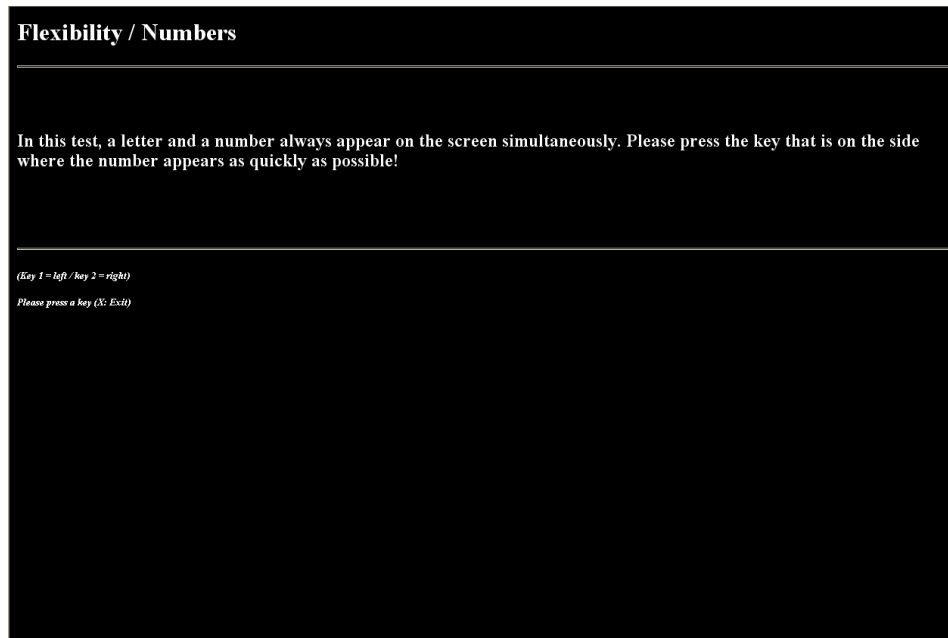
The 'Flexibility' dialog box contains:

- Condition:
- Buttons: OK, Cancel

After a test has been selected a window opens with the ID of the subject and the option to choose between pre- and main test.

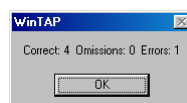


After the selection of the pre- or the main test the program starts with the instructions.

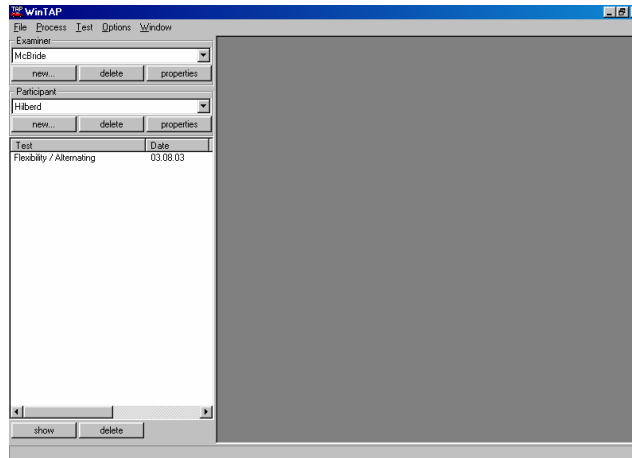


The test can start by pressing any key on the keyboard or with a click on one of the mouse buttons. The test then runs with the default settings. For interruption of the tests see chapter 3.4.8.

At the end of the pre-test, the results (“Correct”, “Omissions” and “Errors”) are presented (see graphic below).



After test administration the data are stored in the subject’s folder (even if the test has been interrupted). The test is then shown in the subject’s list of administered tests. Results can be viewed by clicking one of the tests in the list. If a subject is tested more than once with the same test, the results are listed in chronological order.



If you wish to repeat the pre-test or main test, please start with the same procedure as described above.

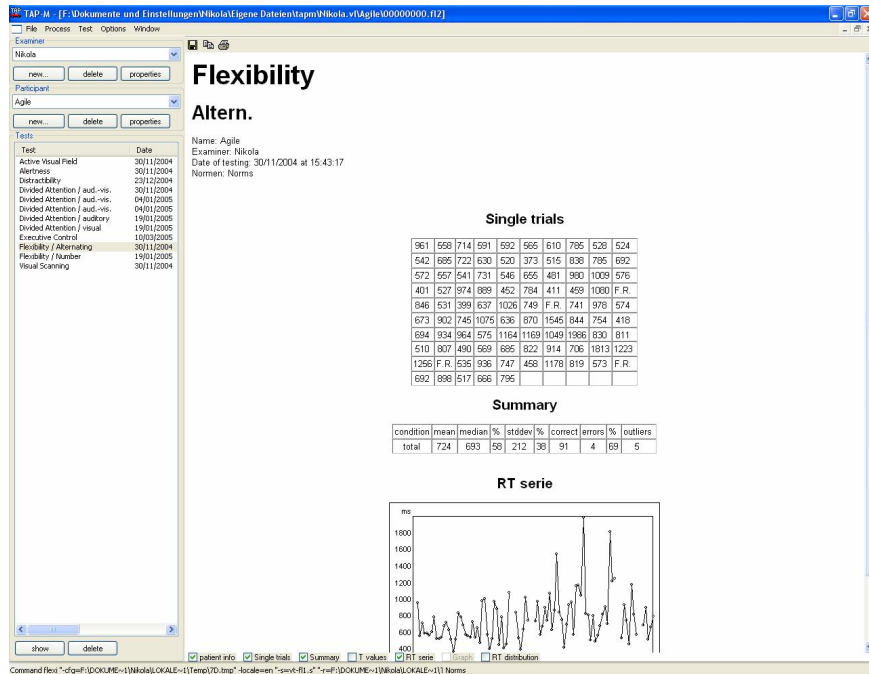
### 3.4.8 Interruption of testing

TAP-M can be interrupted during test administration with the following procedures:

- Press external response key 1 for at least 3 seconds for all tests in which only one response key is needed; press one of the external response keys 1 or 2 for all other tests for at least 3 seconds. Subsequently a message is displayed on the screen asking if the test administration should be stopped (key “x”) or continued (key “c”).
- If the user does not belong to the real-time priority group TAP (see chapter 3.5.1.) other possibilities to interrupt exist
  - Interruption of the test (break): Press “s” or click the right mouse button.
  - Continuation of the test after a break: Press “c” or click the right mouse button again.
  - Exit the test: Press “x” or click the left mouse button

### 3.4.9 Results output

You can select test results in the subject’s test list displayed in the lower left frame with the cursor keys „↓“ or „↑“ and RETURN or with double clicking the left mouse button. The results file maximises automatically in the right frame. An example for result presentation is shown below.



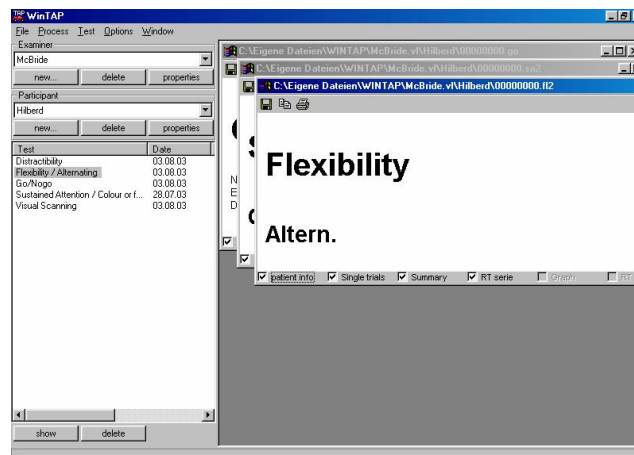
With the options “patient info”, “Single trials”, “Summary”, “T values”, “RT series”, “Graph”, “RT distribution” (if available) at the bottom of the results window you can select one of the different presentation formats.

You can minimise, increase or close the results windows by clicking on the respective button in right upper corner.

If multiple results windows are open at the same time, the different windows can be cascaded with help of the “Window”/”cascades” option.

Results can be saved to the hard disk, copied to the clipboard, or printed. You can do so by either clicking on the buttons in the left upper corner of the windows, or with the menu (by choosing the menu items “Save output”, within the “File” menu, “Copy” within the “Process” menu, or “Print results” within the “File” menu).

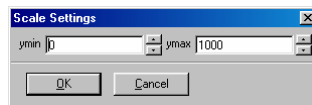
The results of different test administrations can be presented at the same time in “cascades”.



The presentation of the results can be chosen by clicking the upper bar of the results windows. With the menu “window” and the item “cascades” a clearer order of the result output can be arranged.

### 3.4.9.1 Graphics adaptation

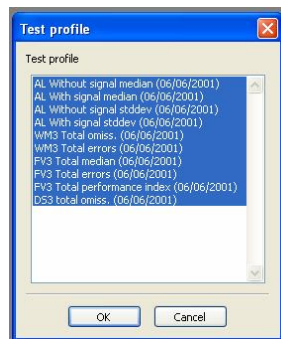
The ordinate's (Y-Axis) range for the presentation of the graphics is set per default from 0 to 2000 msec. By placing the cursor and clicking the right mouse button the window “Scale Settings” is opened. By placing the cursor on this button and clicking the left mouse button the following dialog box appears.



Here the minimum and the maximum value for the ordinate can be chosen.

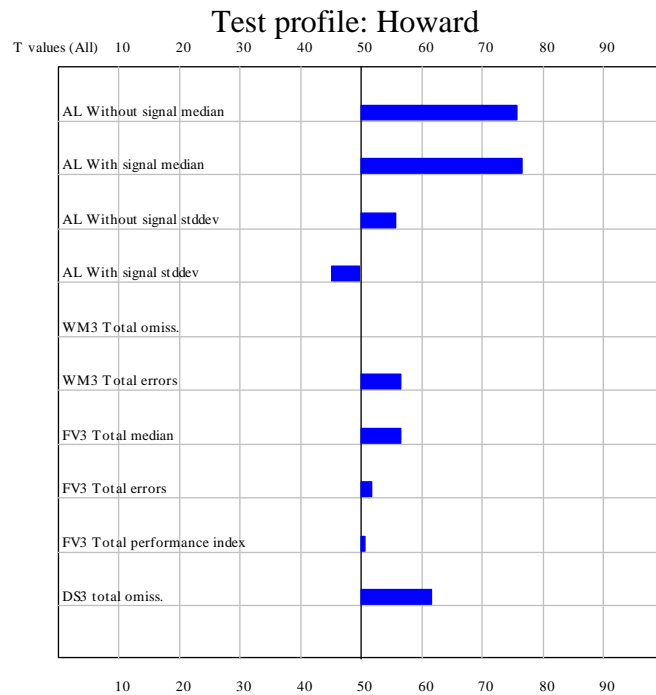
### 3.4.10 Test Profile

The “Profile” button at the bottom of the subject's results list can be used to create a test performance profile for any selection of tests conducted. After clicking the “Profile” button a window is displayed where all tests conducted with this subject are listed.



The test parameters to be included in the profile can be selected by clicking on them with the mouse key or by using the cursor keys.

The test profile shows T values of the crucial test parameters (see figure below). *The displayed parameters were reduced to the crucial ones to keep the profile concise.*

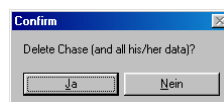


AL: Alertness; WM3: Working Memory / Level of difficulty 3; FV3: Flexibility / letter and number alternating; DS3: Divided Attention I / aud.-vis.

### 3.4.11 Deletion of a data set

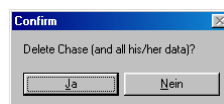
Saved data can be deleted separately or in complete blocks.

From a subject's list of test data, a single test result can be selected with the cursor keys, or by clicking the left mouse button and by activating the button "Delete" at the end of the list. Before deleting, the following security advice is given:



By clicking "Yes" the file is deleted.

By clicking "delete" under the subject's display, a subject's whole data is deleted. Before deleting, the following security advice is given, to avoid losing data accidentally.



It is also possible to delete the data of all subjects being tested by an examiner, by activating the button "delete" below the examiner's display. Before deleting the following security advice is given, to avoid losing data accidentally.



### 3.4.12 How to exit TAP-M

You have different options to quit TAP-M:

- click with the mouse on the button in the right upper corner;
- press “Alt”+ “F4”;
- choose the item “Exit” within the “File” menu.

## 3.5 System information

### 3.5.1 TAP-M and different Windows versions

TAP-M is a Windows application that runs with Windows 2000, XP, and NT.

Test administration with TAP-M requires an exact time measurement with a resolution of milliseconds. To guarantee this, TAP-M requires a high priority which is allocated by Windows during test administration. This inhibits almost every other activity in the system. However, it is recommended to close other programs running in the background.

During installation the program offers the possibility to **create a real-time priority group “TAP”** to which users can be added that receive real-time priority. In the TAP group window during the SETUP of the program, multiple users can be selected by holding the STR-key and selecting the respective users with the left mouse button. However, on some systems this procedure might not proceed correctly (the SETUP program will stop without closing). If this is the case, please manually stop the process GROUP.EXE with STR-ALT-DEL and proceed with the following steps:

- Manually adding the respective local users to the TAP real-time priority group:
  - Click with the right mouse button on the WORKSPACE icon on the desktop
  - Select ADMINISTRATION
  - Select LOCAL USERS AND GROUPS
  - Select GROUPS
  - Double click on TAP displayed in the right window
  - Select ADD...
  - Select EXTENDED

Select the users to be added to the real-time priority group TAP

This step is especially important when the examiner has no administrative rights. If other programs are active in the background during test administration, it is recommended to give real time priority to the examiner during the installation of TAP-M (this can be done by the Administrator). During the installation, the Setup program of TAP-M offers the possibility to create a user folder with the name "TAP". (Please select this during the first installation). Now the administrator has to fill in the examiners' IDs that are authorised to start TAP-M in a real time mode. Selective users can also be deleted from TAP group in the same procedure.

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### 3.6 Installation of TAP-M

To install TAP-M, please insert the program CD into the CD drive, run the setup program and please follow the instructions in the Setup-Program.

During the initial installation the following drivers have to be installed:

- Hardlock driver (“Install the Hardlock Driver”).
- Parallel port driver (“Install Parallel Port Driver”).

If you want to reinstall TAP-M, it is necessary to uninstall the previous version of the TAP-M. To do this, please start the program “unins000.exe” in the TAP-M folder. If there are any existing data that have been collected by test administrations before, they will not be erased!

### 3.7 Data storage

The TAP-M-folder is created within the personal directory of the Windows user. Within the TAP-M folder another subfolder with the examiner’s name (as set within TAP-M) is created with subdirectories for each subject. Raw data from test administrations are stored in the subjects’ folders. The file names contain information about the test they come from (as extension) and how often a participant was tested with this test. For example: “00000001.al” means, that this was the second administration of the test “Alertness” with this subject (the file “00000000.al” denotes the first administration).

The tests can have the following extensions:

1. Distractibility	00000000.dis
2. Active Visual Field	00000000.act
3. Alertness	00000000.al
4. Sustained Attention	
Condition: „Colour“	00000000.sa1
„Position & Colour“	00000000.sa2
5. Executive Control	00000000.ec
6. Flexibility	
Condition: „Number“	00000000.fl1
„Alternating“	00000000.fl2
7. Divided Attention	
Condition: „auditory“	00000000.d1
„visual“	00000000.d2
„auditory-visual“	00000000.d3
8. Go/Nogo	00000000.g1
9. Visual Scanning	00000000.sc

The file “name.pdt” contains the subject’s demographic data.

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## 3.8 Description of the subtests

### 3.8.1 Recently developed subtests

#### 3.8.1.1 Executive Control (pre-screening task)

Since more recent studies show that demented patients can have preserved driving skills until more advanced stages of the disease (Hunt, 1993) the function of a pre-screening procedure should not only be to detect dementia but also to identify people who may be at risk for safe driving. After being referred for further screening, focus should be reoriented towards functionally based measures rather than diagnostic labels (Odenheimer, 1993; Withaar, 2000).

When implementing a pre-screening stage in a diagnostic procedure, it has to be decided which diagnostic criteria should mainly be focused on. The rationale is to maximize the rate of correct and minimize the rate of false positive and false negative decisions as expressed in the following table:

**Table 3.1:** Errors that might occur when a criterion is predicted.

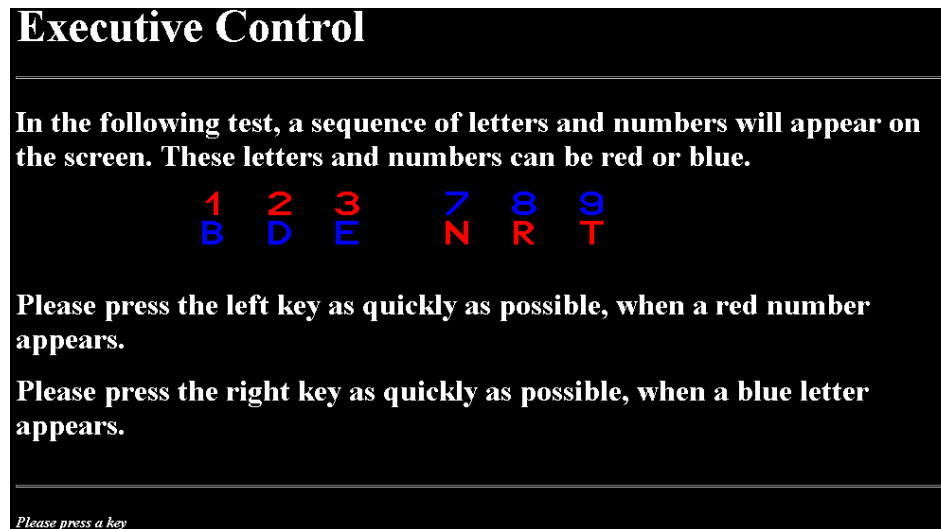
		Driving ability (criterion)	
		+	-
Decision based on pre-screening (predictor)	+	Correct decision	False positive decision
	-	False negative decision	Correct decision

A perfect correlation of predictor and criterion cannot be expected. Instead it will be necessary to maximize the predictive validity that can be achieved in such a diagnostic situation. A way to achieve this is to focus on a subset of functions in a pre-screening assessment that are supposed to play a predominant role in the criterion (driving ability) and that seem to be related to the person group at risk (dementia). If the decision (pre-screening) is based on a very strict standard (with a big number of subjects being rated as impaired), the number of false negatives will be increased but the rate of false positives decreases. With a lax criterion the situation will be vice versa. The impact on the rate of correct decision depends on the base rate of subjects in the interesting population being fit or unfit to drive.

Executive deficits are described frequently even in the early phase of Alzheimer's disease (Nathan et al., 2001). Depending on the localization of the cerebral pathology also visuo-spatial deficits can be found (Mendez et al., 1997). Early signs of dementia (e.g. of the Alzheimer type) are typically word-finding difficulties and (working) memory problems. Learning deficits mainly concern situations in which the learned material has to be recalled without cues and has to be (semantically or phonologically) organized prior to or during learning. These problems are commonly conceived as executive deficits, as an inability of controlling the information flow within working memory, as a reduced mental flexibility, a decreased planning ability and as a deficit in coordinating simultaneous cognitive subtasks (e.g. divided attention; see Gainotti et al., 2001; Brouwer et al., 1991).

The task **Executive Control** measures aspects of working memory, selective visual attention, inhibition and mental flexibility on an intermediate level and could therefore prove valuable as a pre-screening tool in tests for fitness to drive. Preliminary data are presented below (chapter 7, “Validity”), further data analysis will follow.

**Figure 3.1:** Screenshot of the Instruction of EXECUTIVE CONTROL.



The main components involved in this task are:

- Working memory: The associations *red number - left response key* and *blue letter - right response key* have to be kept in mind. This requires a maintenance of the two mental sets *Modality* (number/letter) and *Colour* (red/blue) that have to be applied simultaneously when every stimulus is analysed or in other words, these features have to be integrated.
- Divided attention: The maintenance of two stimulus sets (modality, colour).
- Mental flexibility: Every single stimulus feature can be critical or non-critical depending on the stimulus (e.g. blue numbers or red letters are non-critical but red numbers or blue letters are critical). This requires the flexible handling of these two mental sets.
- Selective visual (focused and non-spatial) attention: Visual stimuli have to be analysed and selectively reacted to.
- Choice reaction: The motor act has to be adapted according to the displayed stimulus.
- Inhibition: Possibly false reactions induced by the colour of the stimulus (as the most predominant feature of the stimulus) have to be suppressed.

The difficulty level of the task is intermediate, since it is not sufficient to keep in mind associations based on single physical aspects of the stimulus (colour OR modality) but it is necessary to rehearse the combinations of both. On the other hand, these stimulus-response associations do NOT change throughout the test but remain fixed.

The task is stimulus-driven and thus will have a fixed duration of about 4.5 minutes without instruction (a pseudo random sequence of 80 trials of which 40 trials are targets). The Inter-Stimulus-Intervall is 2-3 seconds (randomized), every stimulus is presented for 500 msecs. The relevant parameters resulting from this task are reaction time, number of false positive reactions and number of omissions. Thus, the task also gives information of how fast and

precise a subject is able to react to pre-specified but still novel stimulus configurations and places demands on the subjects speed-accuracy control.

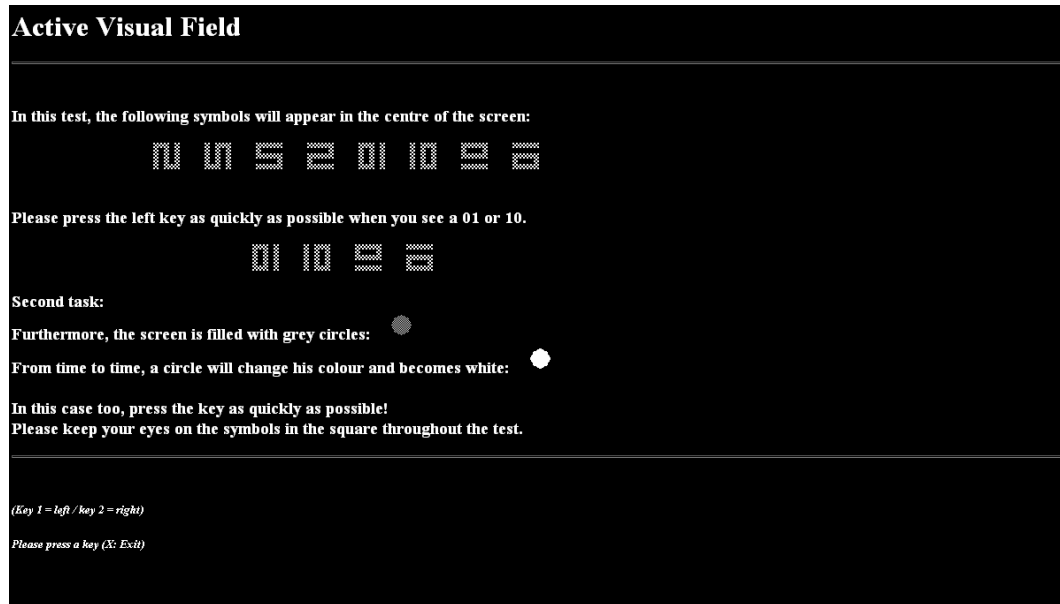
### **3.8.1.2 Active visual field**

With this task the size of the active visual field is measured. The paradigm used requires the detection of colour changes of blue circles that fill the screen. These critical events appear in different spatial locations and eccentricities from the centre of the screen. To ensure fixation and to prevent eye movements to the periphery, a selective visual attention task is presented centrally with the subject having to respond to certain critical stimuli (10 or 01) that can be vertically or horizontally oriented. Both of these tasks (detection of critical stimuli in the centre and detection of a colour change in the periphery) have to be performed simultaneously. In both cases, a response button has to be pressed. The ability to detect stimuli within the visual field when distracting stimuli are present and/or central stimuli have to be additionally focused has repeatedly been shown to be a potential predictor of driving ability (Owsley et al., 1998).

The pretest consists of 30 central and 5 critical peripheral stimuli. During the main test 470 central stimuli and 85 colour changes are presented. The Onset-onset interval of central stimuli is 1500 msec, of peripheral critical stimuli about 3-4 sec. A critical central stimulus remains on the screen until it is detected; the critical peripheral stimulus is shown for 1000 msec and then disappears if it has not been detected in this time interval. The subject has 5 secs to react.

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Figure 3.2: Screenshot of the Instruction of ACTIVE VISUAL FIELD.



### 3.8.1.3 Alertness

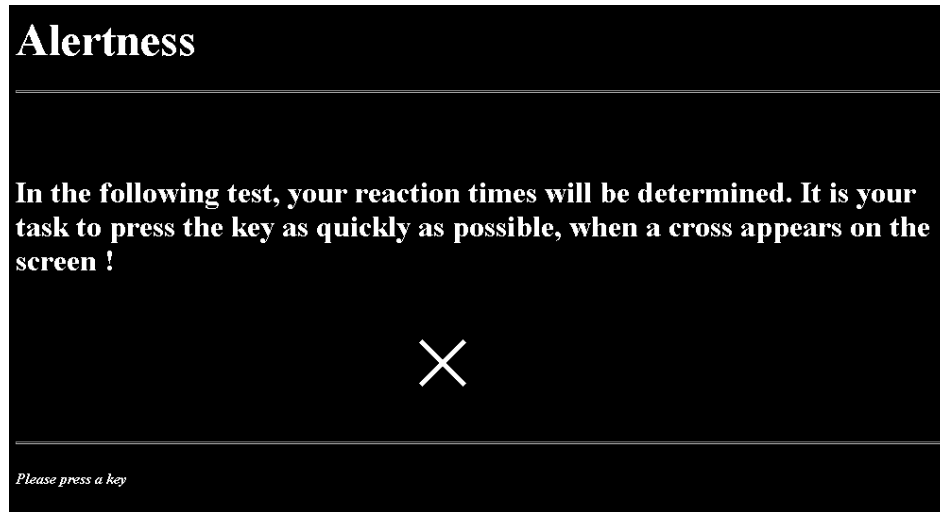
This test is designed to assess tonic alertness (Posner & Rafal, 1987), which is defined as the ability to maintain a high level of responsiveness in anticipation of a test stimulus (Posner & Petersen, 1990). This tonic alertness shows characteristic variations in the course of daytime (Colquhoun, 1982; Babkoff et al., 1991) and might be especially impaired in patients with right cortical or brainstem lesions (Mirsky & Orren, 1977; Mesulam, 1981; Rueckert & Grafman, 1996). In addition, influences of the noradrenergic system on arousal/alertness have been shown by Smith & Nutt (1996) and the dominance of right fronto-parietal cerebral structures for the maintenance of the alertness level could be shown in functional imaging studies (Sturm & Willmes, 2001).

The alertness test measures the simple reaction time in response to a visual stimulus (a cross presented on the monitor).

Simple reaction times give a reliable index of tonic alertness (Fimm, 1988, 1989). The sequence of reaction times during the test procedure can also provide critical information about possible "lapses of attention" (van Zomeren & Brouwer, 1987; Fimm 1988).

In the standard test procedure, 20 trials are presented. If the subject does not respond within 2 seconds, the program automatically enters an idle state and prompts the subject that a response was not recorded. In such cases, pressing the function key F2 will cause the testing to continue. Trials in which the subject anticipates the stimulus (RT less than 100 msec) or does not respond (RT greater than 2 sec) are repeated.

**Figure 3.3:** Screenshot of the Instruction of ALERTNESS.



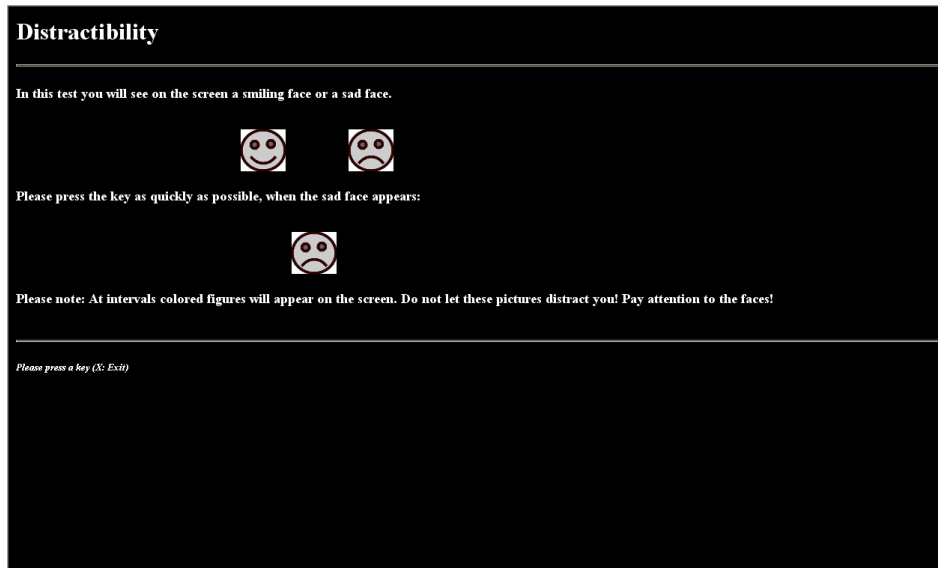
Results: Individual reaction times, mean and standard deviation of the reaction times, as well as the median reaction time is presented. The number of anticipatory responses as well as the number of trials with a late response is also given. The parameter for the alertness response is also presented.

#### **3.8.1.4 Distractibility**

One important basic attentional function is the ability to maintain attentional focus, extract relevant information and suppress potentially distracting stimulation. Especially the ability to prevent distracting information from triggering one's eye movements towards the distracting stimulus can be conceived as essential in car driving, since the main attentional focus in the centre of the visual field should not be triggered by and switched to irrelevant and frequent peripheral stimuli.

This task was developed to measure the ability to maintain a central attentional focus to selectively react to a critical stimulus when distracting visual information is presented. The spatial location as well as the time of presentation of the distractor is unpredictable. The task is explicitly to ignore the distractors and to focus on the centrally presented faces.

**Figure 3.4:** Screenshot of the Instruction of the test DISTRACTIBILITY.



The pre-test comprises 11 and the main test 150 trials. The distractor appears 400 msec before the presentation of the central target and is displayed for 1500 msec. The target is only presented for 200 msec. This time structure of the task ensures that the target will be missed when eye movements towards the distractor are triggered since it is not possible to reorient one's gaze back towards the target in time. The onset-onset interval is 1800-3500 msec, and the subject has 5 sec time to react to the target.

### 3.8.1.5 Sustained Attention

Sustained attention is assigned to the intensity dimension in the taxonomy by van Zomeren and Brouwer (1994). It is defined as the maintenance of selective attention for a longer period of time under a certain pressure. It is crucial to distinguish the term “sustained attention” from “vigilance” which are often used equally but differ both in concept and operationalisation. Conditions of vigilance (monotonous tasks with a low frequency of critical stimuli) are exceptional in practice, whereas tasks that require cognitive effort and volitional control have a high ecological validity. The term “concentration” makes the difference even more obvious: sustained attention means a temporally stretched focus of selective attention, where a stable performance level is maintained volitionally under effort. Tasks of this kind are especially relevant in working conditions (Czaja & Sharit, 1993; Gopher, & Kimchi, 1989; Hancock; Wulf; Thom & Fassnacht, 1990; Hockey, 1993; Tattersall & Hockey, 1995; Zeitlin, 1995). Berberich (1996) showed that this task has a high predictive validity concerning occupational rehabilitation of brain-damaged patients.

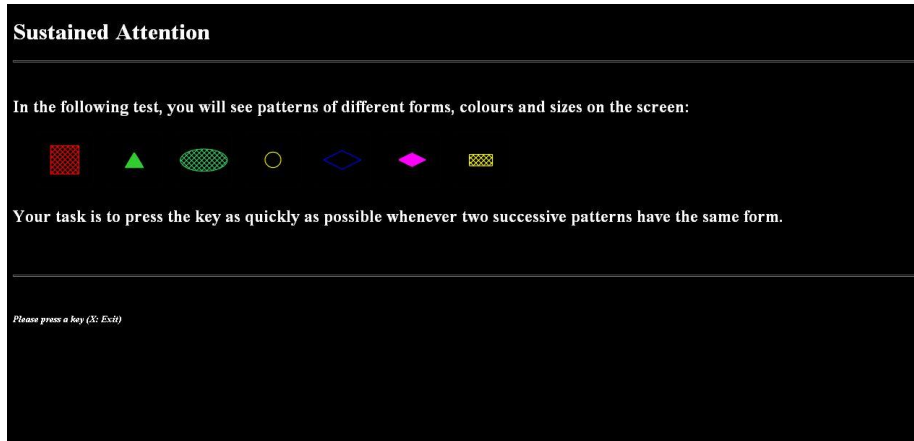
The subject is presented stimuli on the screen that differ in several feature dimensions: colour, form, size, and filling. If a given stimulus is identical in one or two of the previously defined stimulus dimensions to the previous stimulus, the reaction key is to be pressed. The task can be adapted to the subject's performance level by choosing one of two levels of difficulty (level 1: “form”, level 2: “colour or form”).

Apart from working memory, further attentional components are involved in this task: The variation of stimuli in several dimensions requires a specific form of selective attention as one or two critical dimensions have to be focussed on while ignoring other dimensions. On the second level of this task, the ability to divide attention is additionally required. The

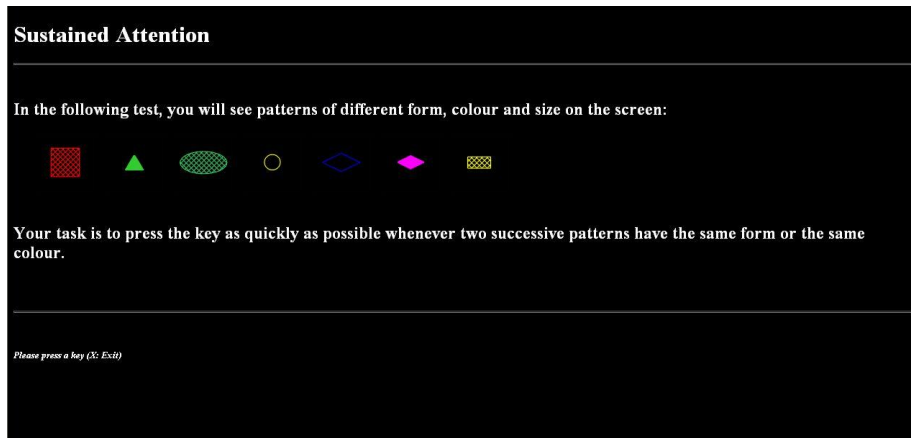
continuous re-orientation to changing stimuli and dimensions also requires a certain amount of flexibility.

The pre-test consists of 20 trials, 4 of which are critical. The main test contains 1000 trials per condition and has a constant length of 15 minutes.

**Figure 3.5:** Screenshot of condition 1 – sustained attention



**Figure 3.6:** Screenshot of condition 2 - sustained attention



### 3.8.2 Already existing TAP/TAP-K subtests

#### 3.8.2.1 Divided Attention

Real-life situations often demand that our attention be simultaneously divided between different on-going events (Lane, 1982). Brain-damaged patients often complain that they have difficulty in situations in which two or more tasks have to be performed in parallel (van Zomerén & van den Burg, 1985). These considerations have provided the motivation to include a test for divided attention in the present battery. Objective tests already conducted in several investigations substantiate the assumption that patients have difficulty in attending to more than one task at any given time (Matthes, 1985; Goldstein and Lewin, 1988; König, 1988; Sohlberg & Mateer, 1989). Also the problems experienced by patients in the paced auditory serial addition task (PASAT, Gronwall & Sampson, 1974) appear to be related to difficulties in dividing attention (van Zomerén & Brouwer, 1987).

The impairment in performance under conditions demanding divided attention becomes critical for many patients, who experience that a previously "automatically" performed task now has to be performed with intense attentional control (Hirst, 1982; Wood, 1984).

Despite the clinical importance of an impairment in performance on divided attention tasks, it remains controversial whether attention has a limited capacity (Neumann, 1985; Neumann et al., 1986).

It has also been questioned whether divided attention is a specific function at all (Lane, 1982; Lansman, Potrock & Hunt, 1983; Brouwer, Ponds, van Wolffelaar & van Zomerén, 1989). It also remains controversial whether an impairment in divided attention is caused by a reduced "attentional capacity", by an overall reduction in performance speed (van Zomerén et al., 1984; Brouwer et al., 1989), by problems with "time-sharing" (Lansman et al., 1983), by a problem with shifting between tasks, or by a reduced efficiency in coordinating different demands in an integrated activity (Brouwer et al., 1989).

Divided attention can be assessed in a "dual-task" paradigm, in which two stimuli have to be attended to simultaneously. The tasks should be selected such that structural interference does not arise between the information channels (Kahneman, 1973).

In the present test, divided attention is assessed by a simultaneous visual (detection of a square among crosses) and auditory (detection of irregularities in a sequence of tones) discrimination task. The control condition is to test performance when these tasks are performed separately.

The experimenter has to choose between either of the single tasks (visual, auditory) and dual task.

The number of trials is set to 100 for the visual discrimination task and 200 for the auditory task.

**Figure 3.7:** Screenshot of the Instruction of condition 1 (Tones) of DIVIDED ATTENTION.



## Divided Attention / Sounds

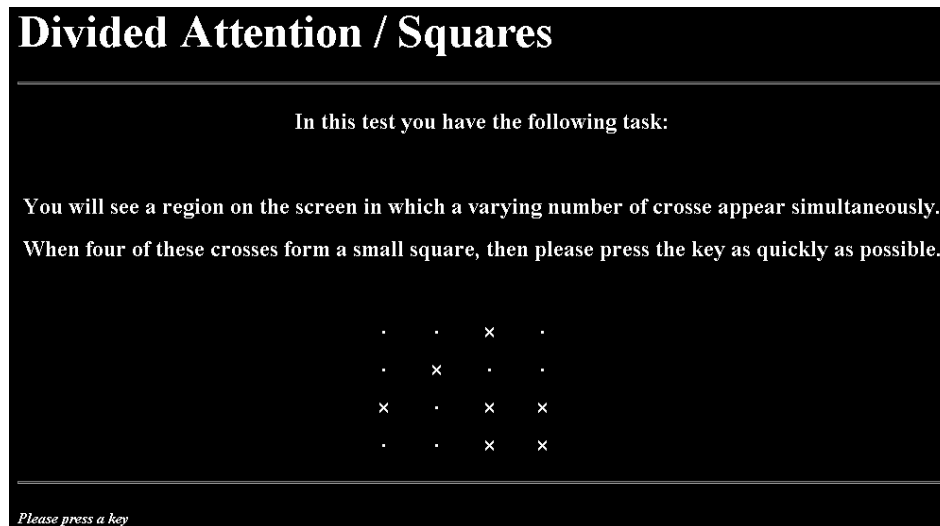
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**In this test, you will hear a high and a low tone in sequence. You must decide whether the same tone occurs twice in a row. Then please press the key as quickly as possible.**

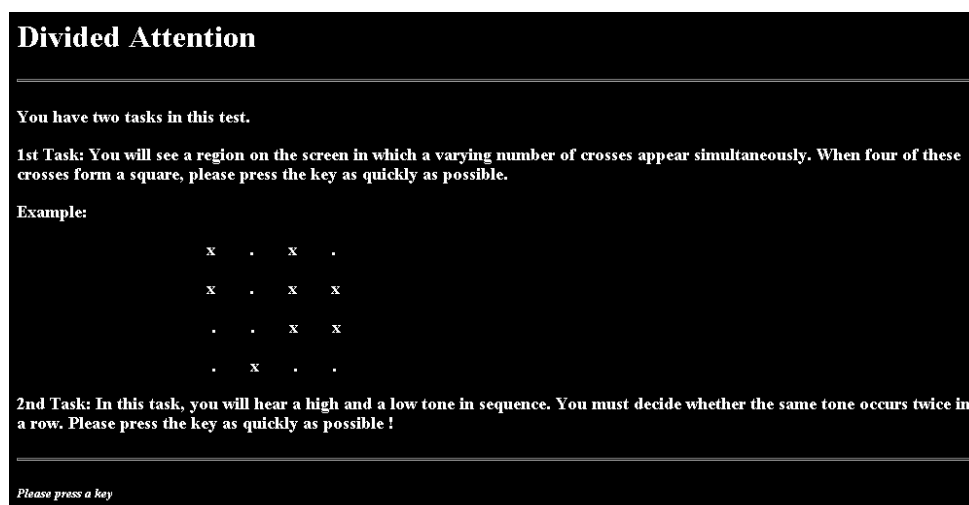
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*Please press a key*

**Figure 3.8:** Screenshot of the Instruction of condition 2 (Squares) of DIVIDED ATTENTION.



**Figure 3.9:** Screenshot of the Instruction of condition 3 (Squares and tones) of DIVIDED ATTENTION.



**Results:** The trial number, type of task (visual, auditory), the number of correct and incorrect responses, and the reaction times for correct responses are given. In addition, the number of correct and incorrect responses (missed signals, false positives), outliers, as well as median values, means and standard deviations are presented. A graphical presentation is optionally given of the median reaction times for the visual and auditory tasks.

### 3.8.2.2 Flexibility

Selective attention demands, in addition to the ability to focus attention to certain stimulus features, to be able to shift this focus of attention to different stimulus features, which represents an important key to flexibility. According to Zubin (1975), three aspects of attention should be differentiated: 1) the selection of a critical part of a stimulus array, to which attention should be focused; 2) the ability to maintain this focus; 3) the ability to shift this focus to another stimulus feature or part of a complex visual scene.

Mirsky (1989) claims that the shift function is based in prefrontal mechanisms whereas Lynch, Mountcastle, Talbot and Yin (1977) suggest that parietal structures are involved in shifting of attention. Posner et al. (1984) state that the parietal cortex is also involved in "disengagement" of attention, which is a prerequisite for "moving of attention". The role of frontal structures in the ability to shift between different sets has been documented in frontal lobe patients by Milner (1963) using the Wisconsin Card Sorting Test, and other procedures discussed by Walsh (1978).

It remains to be determined whether these low-level sensory-related functions of attention also hold for higher level cognitive processes, for example, in the shifting between different mental sets. The concept of rigidity is basically the lack of flexibility in dealing with complex cognitive tasks. According to Walsh (1978), it remains open whether individual differences in rigidity, even in healthy subjects, can be derived from a single unitary factor. The fact that little has been documented in the neuropsychological literature on various forms of inflexible behavior suggests, according to Walsh (1978), that the relationship between rigidity and brain mechanisms remains undetermined.

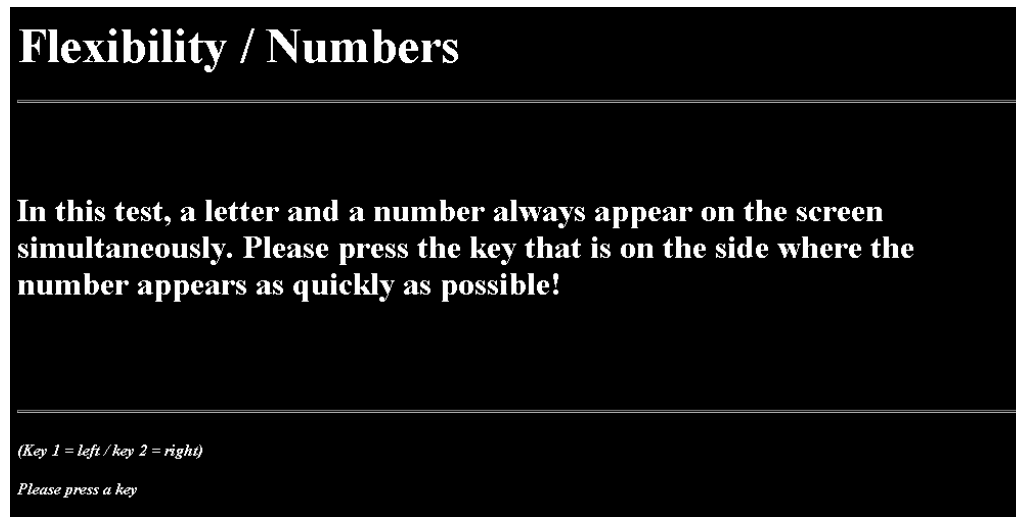
The practical importance of the ability to shift the focus of attention is obvious: preservation and distractibility are the ends of a continuum along which the ability to shift the attentional focus varies. This ability is an important prerequisite of the general mental flexibility demanded in many cognitive tasks (Sohlberg & Mateer, 1987; 1989).

In the present test, competing stimuli are presented simultaneously left and right of the fixation point. The subject is instructed to press the response key on the side containing the target stimulus. Target stimuli are either letters or digits. In the simple task, the digit always represents the target stimulus. In the complex task, which demands attention to be shifted, the target stimulus alternates from one trial to the next between a letter and a digit. The task demands that the subject alternate between the two classes of target stimuli. The simple task (with constant target stimuli) serves as an indication whether the patient is able to discriminate between the target stimuli and press the appropriate response key.

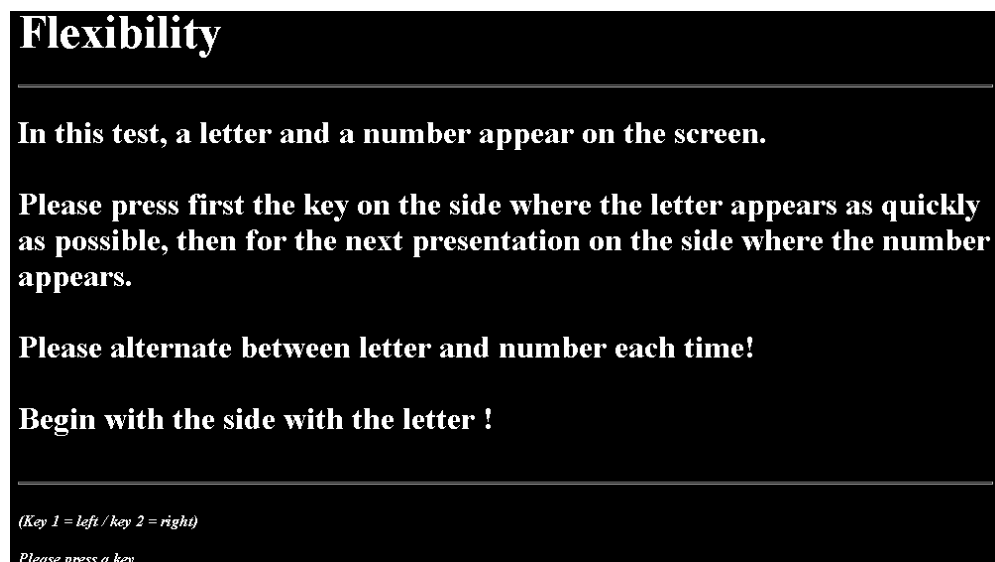
After starting the test, the experimenter should choose between the simple task (with constant target stimuli) or the complex task (with alternating target stimuli). The program is set to give 50 (simple task) or 100 (complex task) trials.

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**Figure 3.10:** Screenshot of the Instruction of Condition 1 (numbers) of FLEXIBILITY.



**Figure 3.11:** Screenshot of the Instruction of Condition 2 (alternating) of FLEXIBILITY.



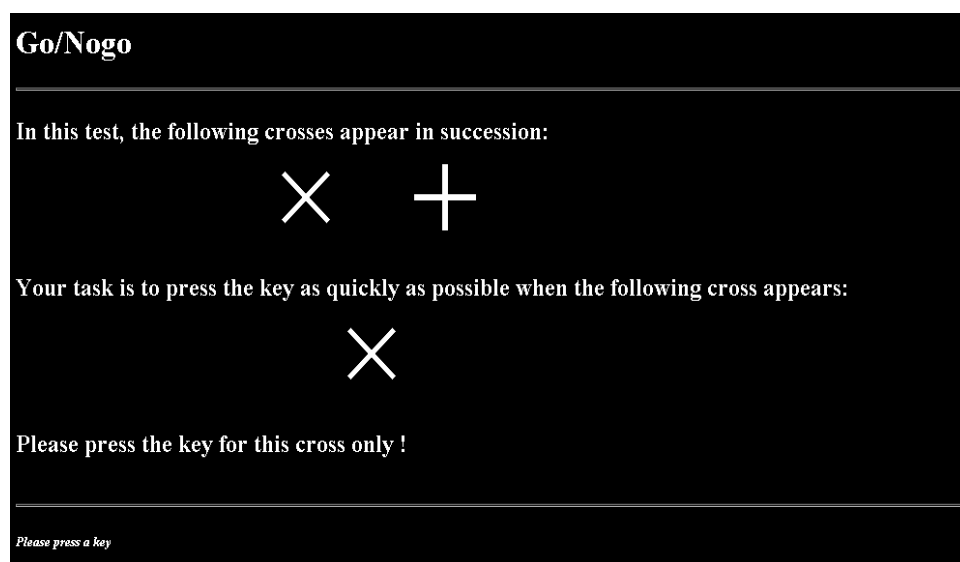
Results: A trial-by-trial protocol of the responses (correct, incorrect) and the reaction times is given. For the overall results, the number of correct and incorrect responses are given, along with the median reaction time, number of outliers, and the mean and standard deviation of reaction times for correct responses. These are shown for results from the simple and complex task, with constant or alternating target stimuli respectively.

### 3.8.2.3 Go/Nogo

The Go/No-go test has been designed to assess the specific ability of subjects to suppress undesired responses, an ability which is especially disturbed following prefrontal lobe lesions. Luria (1966) refers to a "disturbed voluntary motor control" in patients with frontal lobe damage. Drewe (1975a,b) could, in part, replicate the findings of Luria (1966), whereas Verfallie and Heilman (1987) only found an impairment in patients with right frontal lobe

damage. Heubeck (1989) found deficits in the Go/No-go test in patients with fronto-lateral but not fronto-medial lesions. Heubeck (1989) could not substantiate a significant right-left sided difference. Some patients with temporal lobe lesions also showed impairment on this task. After analysing a substantial amount of patient data, Fimm (1988) concluded that a specific factor, which he refers to as "response-selection performance", is impaired in these patients. The present test should assess a subject's ability to suppress unwanted responses to irrelevant stimuli, as well as determining the choice reaction time under conditions of stimulus selection (compare the simple reaction time task given in the Alertness Test). Reaction times and errors are recorded in a simple Go/No-go test with two stimuli ( + and x; 2 stimuli, 1 critical stimulus).

**Figure 3.12:** Screenshot of the Instruction of GO/NOGO.



Results: The number of correct responses and errors (missed critical stimuli and false positives) are given, along with median reaction times, means, standard deviations, and outliers.

### 3.8.2.4 Visual Scanning

This test is designed to assess the subject's ability to search for specific visual features present in complex displays (referred to as "visual scanning": Teuber, 1964; Luria, 1966; Lhermitte, Derouesné & Signoret, 1972). The task is to discover the presence of a critical feature in a 5x5 matrix of stimuli, which demands a number of basic functions to be intact. Task performance can be impaired by a disorder in eye movements, by the way the subject systematically scans his/her visual field, or by a reduced attention capacity. The complexity of the processes and neural mechanisms which underlie eye movements has already been discussed in the Introduction. The inability to search for items in complex displays is most prominently disturbed in patients with visual neglect (e.g., Heilman, 1979; Rizzolatti & Gallese, 1988; Weintraub & Mesulam, 1989). Impairments in the ability to systematically scan complex visual displays have also been observed in patients with frontal lobe damage, who show no obvious signs of neglect (Luria, Karpov & Yarbuss, 1966; Walsh, 1978; Zihl & von Cramon, 1986; Weintraub & Mesulam, 1989). An extreme form of impaired visual search can be

observed in patients with Balint's syndrome (Zihl & von Cramon, 1986; Newcombe & Ratcliff, 1989).

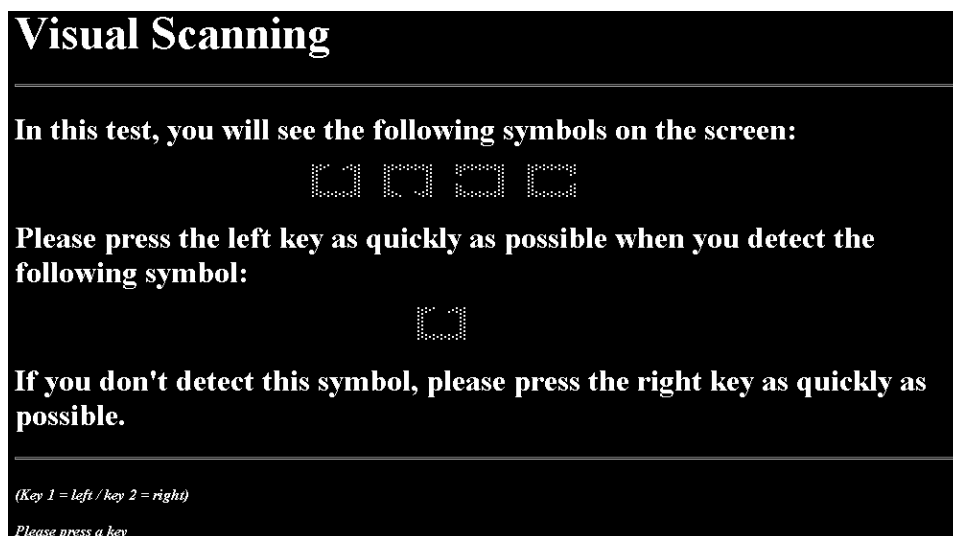
A performance deficit in this test would normally require further, more specific testing, owing to the complexity of the various underlying functions. This test can therefore be useful as a screening tool.

The stimulus display consists of a matrix of squares, which have a single gap in one of their four sides. The matrix is made up of 5 rows of 5 uniformly spaced squares. The critical stimulus is a square that has a gap on the upper edge (i.e., open upwards), which may be contained in the matrix or may not. The subject should respond as quickly as possible when he/she discovers the critical stimulus in the display.

The reaction time gives an index for the systematic nature of the serial search performed by the subject. A row-by-row search for the critical stimulus should lead to a linear relationship between the position of the critical stimulus and the reaction time.

The program is set with a default value of 100 trials (50 with critical stimuli, 10 for each row).

**Figure 3.13:** Screenshot of the Instruction of Visual Scanning.



The subjects should be instructed to search through the matrix row by row, as if they were reading. Afterwards, in a retest, the subjects can be instructed to search through the matrix by columns. This change of instructions is a further test of the subject's ability to change strategies in complex cognitive tasks, an ability that is often impaired in frontal lobe patients. The search strategies used by the subjects reveal themselves in the pattern of reaction times (see below, Results).

After giving the subject the instructions, an example of a stimulus display is given to demonstrate the task. During the run, an example of the critical stimulus is presented in the upper left-hand corner of the display (see Figure), so that the subject does not forget which stimulus he/she is searching for.

**Results:** A trial-by-trial account of the reaction times is given. For trials with and without the critical stimulus separately, the subject's response and the median reaction times are recorded, along with the mean and standard deviation. The median, mean, and standard deviations of the reaction times for detection of the critical stimulus are given separately by column for the different stimulus positions as well as the number of detected and missed stimuli (maximum 10 per column for 100 trials).

A graphical display of the median reaction times for the detection of the critical stimuli for the various stimulus positions is given, along with total search time for trials without the critical stimulus.

### 3.8.3 Duration of the tests

The following table displays the duration of the different subtests of the TAP-M without time for test instruction.

**Table 3.2: Duration of the TAP-M subtests without time for test instruction**

Test	Duration (in minutes)
Executive Control (pre-screening)	<b>3.5</b>
Active visual field	<b>12</b>
Alertness	Approx. <b>3</b> (test is partly response-driven)
Distractibility	<b>6</b>
Divided Attention (visual-auditory)	<b>4</b>
Flexibility	Approx. <b>5</b> (Test is response-driven)
Go/Nogo	<b>3</b>
Sustained Attention	<b>15</b>
Visual Scanning	Approx. <b>9</b> minutes (Test is response-driven)

## 4 Methodological considerations

### 4.1 How attentional performance is evaluated by TAP-M

Parameters of performance speed and performance quality can be drawn on as a criterion for performance on the Test for Attentional Performance (TAP). These are reaction times and correct reactions as well as invalid reactions. All measurements of the time taken to execute correct reactions are evaluated as valid *reaction times*. These are all reactions that are not *false alarms*, *omissions*, or reactions outside the permitted time window (*anticipations*: reaction times below 100 msec; *outliers*: reactions beyond the participant's normal range). These criteria can be used to ascertain various parameters assessing different aspects of performance capacity.

The evaluation and standardization procedures treat the number of correct reactions and the reaction times separately, although, in the sense of a speed-accuracy trade-off, they should certainly not be evaluated as being independent. However, a workable standard parameter for this has yet to be proposed in the literature.

### 4.2 Test Parameters

#### Parameters of Performance Quality

- The most important parameter here is the *number of correct reactions*. The correctness of reactions is determined by exclusion criteria: Correct reactions are all those that are not false and occur within the permitted time window.
- The *number of false alarms* is compiled from all reactions to a non-critical stimulus. This serves as a criterion for *impaired selectivity* of attention.
- The *number of omissions* reports the frequency with which no key response is given to a critical stimulus. It is an important *indicator for inattention*.

#### Parameters of Performance Speed

- The *median of reaction times* is the most appropriate parameter for the average reaction time, because reaction times frequently do not show a normal distribution. A higher median is either a *measure of general slowness* when this increase is consistent across all procedures, or an *indicator of the specific problems* that the patient has in processing this test when the average reaction time deviates from the average performance speed on the rest of the procedures.
  - The *arithmetic mean of the reaction times* is the most frequently used measure for reporting the distribution of reaction times. However, this measure is rather unreliable because of the skewed distribution.
  - The *standard deviation of the reaction times* is a sound measure of variability and thus an indicator for the *variation in attention*. When variability is clearly higher, the exact distribution of the reaction times should be inspected in the graphic display, in order to determine whether this variation in attention is a consistent characteristic or whether it occurs in phases in the sense of lapses of attention.
-



- Drawn on the distribution of the individual reaction times, *lapses* represent delayed reactions. They are a measure of *lapses of attention*. Reactions are evaluated as lapses when the reaction time is longer than the *individual mean plus 2.35 times the standard deviation*. Related to the individual variability of reaction times, such values should only occur with a probability of less than 1%. If lapses are registered, the distribution parameters of reaction time (median, mean and standard deviation) are recomputed without them. This identification of and correction for lapses is performed only once. In other words, it is not reiterated several times.
- *Anticipations* are reactions with reaction times below 100 msec. Because it is impossible to react so quickly, these cannot be responses to the current stimulus. They are an *indicator of an inability to inhibit reactions*.

#### 4.2.1 Computation of Norms

Norms are available for a series of procedures and various implementation conditions. The basic data were collected from healthy controls in various surveys. **Data were collected from healthy subjects, predominantly participating in examinations of driving abilities and therefore comparable in their emotional state to the target population of this test battery.**

For each test, norms were computed as a *percentile rank* (PR) and as a *T score* for each of the above-mentioned parameters (if normative values are available and reasonable).

##### 4.2.1.1 Output of uncorrected normative values

For assessing a person's fitness to drive, it can be interesting to compare the individual to a total sample without any correction for age effects. Therefore, as a default option, norms are displayed uncorrected based on the normative sample described above.

##### 4.2.1.2 Age-and gender-correction of norms

To determine age and gender effects without the influence of lapses in the normative sample, an iterative process of excluding extrema was conducted. A correction for educational levels did not seem valuable in the context of driving skills assessment.

At first, influences of age and gender were eliminated via stepwise multiple regression analysis (see above). All cases with a standardized residual value above 2.5 or below -2.5 were then excluded from further analysis. This procedure was repeated until all data with a high deviation from the sample were eliminated. All remaining cases were included in the analysis of age and sex influences. Calculation of corrected data and determination of normative values was then conducted with the complete sample (including lapses).

The following steps were conducted within the analysis:

At first, a trend for influences of sex and age (including square and cubic age effects) as well as the respective interactions (age x sex, age<sup>2</sup> x sex, age<sup>3</sup> x sex) is eliminated from the raw data (step 1). To take into account that variability changes dependent on age, i.e. the homogeneity of age groups differs, all influences of age, sex, square and cubic age effects as well as the above mentioned interactions are eliminated from the trend corrected residuals. This is done by conducting a multiple regression analysis with the absolute values of these trend corrected residuals (step 2). Finally, the corrected initial values are "reconstructed" considering the reduced deviation and explained variance. At first, the absolute values of

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residuals are “reconstructed” (step 3), after that the initial residuals with correct algebraic signs (step 4), and finally the initial values (step 5).

**Step 1:**

$$\text{Score}_{\text{res}} = \text{Score} - (c_0 + c_1 * \text{sex} + c_2 * \text{age} + c_3 * \text{age}^2 + c_4 * \text{age}^3 + c_5 * \text{dummy1} + c_6 * \text{dummy2} + c_7 * \text{dummy3} + c_8 * \text{dummy4} + c_9 * \text{dummy5} + c_{10} * \text{dummy6})$$

**Step 2:**

$$\begin{aligned} \text{dev}_{\text{trend}} &= |\text{Score}_{\text{res}}| \\ \text{dev}_{\text{trend}_{\text{res}}} &= \text{dev}_{\text{trend}} - (d_0 + d_1 * \text{sex} + d_2 * \text{age} + d_3 * \text{age}^2 + d_4 * \text{age}^3 + d_5 * \text{dummy1} + d_6 * \text{dummy2} + d_7 * \text{dummy3} + d_8 * \text{dummy4} + d_9 * \text{dummy5} + d_{10} * \text{dummy6}) \end{aligned}$$

**Step 3:**

$$\text{dev}_{\text{absolut res}}' = \bar{X}_{\text{absolut reg}} + \text{dev}_{\text{absolut res}} / \sqrt{1 - R_{\text{absolut}}^2}$$

**Step 4:**

$$\text{If } (\text{Score}_{\text{res}} < 0) \text{ Score}' = \bar{X}_{\text{Score reg}} - \text{Abw}_{\text{absolut res}}' / \sqrt{1 - R_{\text{Score}}^2}$$

$$\text{If } (\text{Score}_{\text{res}} \geq 0) \text{ Score}' = \bar{X}_{\text{Score reg}} + \text{Abw}_{\text{absolut res}}' / \sqrt{1 - R_{\text{Score}}^2}$$

TAP-M reports norms **with and without age-correction** respectively that are based on the whole standardization sample (in this case 20-69 year old subjects). For this option, you can choose the respective normfile in the “Options” menu (see above).

## 4.2.2 Interpretation of normative values

Percentile ranks below 25 (T scores below 43) correspond to a performance below average. Average performance (the mean 50 % of the standardization value) means percentile rank 25 to 75 (T score 43 to 57). Percentile ranks above 75 (T scores above 57) stand for a performance above-average.

## 4.2.3 Available norms

### 4.2.3.1 Newly developed subtests

At the moment, no norms for these subtests are available.

### 4.2.3.2 Already existing TAP/TAP-K subtests

Existing normative data of the subtests Alertness, Divided Attention, Go/Nogo, Flexibility and Visual Scanning were collected in own studies and made available by the following persons / institutions:

- Dipl. Psych. N. Franke, Neuropsychologische Praxis, Bonn
- Rheinische Bahngesellschaft AG, Düsseldorf
- Dr. Mehnert, Betriebsärztliche Praxis, Paderborn
- Dr. Lüdemann, Betriebsärztliche Praxis, Düsseldorf
- Dipl. Psych. Hoffmann, Neuropsychologische Praxis, Meckenbeuren
- Dr. Bieberbach, Betriebsärztliche Praxis, Hannover

The normative data of the already existing subtests of the testbattery are given in Table 4.1-4.6.

**Table 4.1:** Norms sample of the subtest “Visual Scanning”.

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	26	11	4	1	42
30-39 years	33	14	5	3	55
40-49 years	36	8	2	2	48
50-59 years	93	6	5	0	104
60-69 years	77	3	4	0	84
Total	265	42	20	6	333

**Table 4.2:** Norms sample of the subtest „Flexibility/Alternating“

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	8	13	10	15	46
30-39 years	9	16	12	9	46
40-49 years	7	10	12	9	38
50-59 years	13	8	17	9	47
60-69 years	19	15	19	14	67
Total	56	62	70	56	244

**Table 4.3:** Norms sample of the subtest „Flexibility/Number“

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	3	8	5	10	26
30-39 years	4	11	6	5	26
40-49 years	2	5	7	4	18
50-59 years	7	4	11	4	26
60-69 years	7	5	7	6	25
Total	23	33	36	29	121

**Table 4.4:** Norms sample „Divided attention/visual-auditive“

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	8	16	7	17	48
30-39 years	6	13	6	9	34
40-49 years	7	8	9	6	30
50-59 years	13	6	16	5	40
60-69 years	19	17	17	11	64
Total	53	60	55	48	216

**Table 4.5:** Norms sample “Go/Nogo”

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	20	38	12	28	98
30-39 years	10	23	13	14	60
40-49 years	8	11	14	10	43
50-59 years	12	8	17	10	47
60-69 years	15	10	15	10	50
Total	65	90	71	72	298

**Table 4.6:** Norms sample „Alertness“

	Male		female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	59	37	39	24	159
30-39 years	40	14	30	7	91
40-49 years	47	4	45	7	103
50-59 years	45	7	45	8	105
60-69 years	39	16	23	5	83
70-80 years	11	3	13	8	35
Total	241	81	195	59	576

**Table 4.7:** Norms sample “Visual Scanning”**Tabelle 0.1**

	Male		Female		Total
	< 12 yrs of education	>= 12 yrs of education	< 12 yrs of education	>= 12 yrs of education	
20-29 years	26	11	4	1	42
30-39 years	33	14	5	3	55
40-49 years	36	8	2	2	48
50-59 years	93	6	5	0	104
60-69 years	77	3	4	0	84
Total	265	42	20	6	333

## **5 Objectivity**

### **5.1 Objectivity of implementation**

All tests are implemented under standardized instructions on the computer screen. Additionally, comprehension of the instructions should be ensured with a pre-test. The pre-test can be repeated several times when this seems to be indispensable for a sufficient understanding of the course of the test. As soon as the pre-test has been completed without error, participants should switch to the main test.

### **5.2 Objectivity of results analysis**

Results analysis is performed automatically and therefore objectively.

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## 6 Reliability

### 6.1 Newly developed tasks

Data collection is still in progress for the newly developed tasks. A detailed analysis will follow.

### 6.2 Already existing TAP/TAP-K subtests

#### 6.2.1 Split-half and odd-even reliability

Split-half and odd-even coefficients are considered to be appropriate measures of reliability in reaction time tasks. Whereas split half is quite sensitive concerning inter-individual trend differences, odd-even can be modified by outliers or lapses of attention. Therefore, both are computed for the existing tests.

**Table 6.1:** Reliability coefficients of existing TAP subtests (based on reaction time).

Test	Split-Half	Odd-Even
Alertness <sup>1</sup>	0.999	0.998
Go/Nogo	0.998	0.998
Divided Attention / squares	0.976	0.982
Divided Attention / tones	0.996	0.994
Divided Attention / Squares and tones		
Whole test	0.993	0.990
Squares	0.985	0.982
Tones	0.989	0.987
Flexibility / numbers	0.965	0.987
Flexibility / letters and numbers	0.959	0.986
Visual Scanning		
Non-critical trials	0.936	0.995
Critical trials	0.900	0.928

<sup>1</sup>This is an extended version of the Alertness subtest

Reliability coefficients based on the reaction time measure prove to be very high in all tests.

## 7 Validity

### 7.1 Description of validity studies

#### 7.1.1 AGILE project

In the context of the EU-co-financed project AGILE (AGed people Integration, mobility, safety and quality of Life Enhancement through driving) an assessment system for elderly drivers was developed containing self ratings, a neuropsychological test battery, tests in driving simulators, on-road tests etc. Subsequently the modules should be integrated into a paneuropean assessment for elderly drivers. The assessment was conducted on different levels:

- On a first level a paper & pencil-test was conducted to assess elderly drivers who were assigned to the procedure due to medicinal or other reasons that made it necessary to decide if further testing is required.
- On the second level an in-depth medical examination as well as neuropsychological testing was applied.
- On the third level the driving abilities of elderly drivers with observable problems was conducted either in a driving simulator or with the help of a standardised on-road test.

For further project information, please visit [http://www.agile.iao.fraunhofer.de/index\\_all.html](http://www.agile.iao.fraunhofer.de/index_all.html)

On the second assessment level TAP-M was applied and a validation was conducted with the help of data from the third level.

The demographical data of participants is presented in table 7.1.

**Table 7.1:** Participants in the AGILE project

	<i>CARA</i>	<i>HIT</i>	<i>VTI</i>	<i>Total</i>
<b>N</b>	85	100	54	239
<b>% male</b>	67,7	94	48,1	76,6
<b>% female</b>	23,7	6	51,9	23,4
<b>Mean Age</b>	78,79	66,8	70,55	71,91
<b>SD Age</b>	4,96	6,74	9,03	8,6
<b>Min. Age</b>	63	41	34	34
<b>Max. Age</b>	89	81	90	90
<b>% no education</b>	5,4	2	3,7	3,8
<b>% special education</b>	0	11	1,9	5
<b>% primary education</b>	32,3	55	16,7	39,3
<b>% secondary education</b>	30,1	13	20,4	21,8
<b>% A-level</b>	23,7	19	57,4	30,1

Explanation of abbreviations:

- CARA=Belgian Institute of Road Security
- HIT= Hellenic Institute of Transport
- VTI= Swedish Road and Transport Research Institute



### **7.1.2 Basel Study of the Elderly (BASEL)**

This work was a part of a prospective study on the development of dementia at the geriatric university clinic in Basel/Switzerland and was funded by the “Schweizer Nationalfonds”. A Panel of 740 subjects was medically and neuropsychologically examined („Basel Study of the Elderly“; BASEL). The neuropsychological investigation consisted of a detailed diagnostic of attentional functions and furthermore of a questionnaire that the subjects had to complete. Its content concerned actual driving performance, dependence of the usage of the car, participations in accidents, the subjective feeling of safety at driving, questions regarding strategic and tactical driving behaviour. Results are shown below.

### **7.1.3 BIVV/CARA**

In an attempt to identify variables that best predict a team’s decision of driving ability in stroke patients from a pre-driving assessment a retrospective study of a two-year pre-driving evaluation was conducted at the Belgian Institute for Road Safety by Akinwuntan et al. (2002). They examined 104 patients with sequel of first stroke. 41 patients (39.4%) were judged suitable, 45 (43.3%) not immediately suitable and 18 (17.3%) not suitable to drive. Results of this study are displayed under ...

### **7.1.4 Aachen University Hospital**

At the Neurological Department of the University Clinic Aachen there is an in-patient rehabilitatory unit for aphasia patients, i.e. patients with language disorders after a cerebral stroke. A part of these patients is examined for driving skills, including neuropsychological testing as well as on-road assessment. Driving behaviour in the on-road test is rated by a specially advised driving instructor in 283 items and a global score in the style of German school grades. The neuropsychological assessment includes the TAP subtest “Divided Attention”.

From 1996 to 1999 40 patients in the age of 18-68 years (Mean=47.03; SD=13.63), 30 of which being male and 10 female (education: 21 primary education, 10 secondary education, 9 A-level) were assessed.

Of these 40 patients, 24 participated in a driving test, 16 patients withdrew from taking a driving test due to psychometric test results, or were informed that a driving test would not be recommended due to their current capability.

Of the 24 patients participating in the driving test, 23 passed the test, and 1 patient failed.

## **7.2 Factorial Validity**

### **Factor structure of the tests**

The following analyses are based on the AGILE study presented above in 7.1.1.

A principal components analysis was conducted separately for the three test sites as well as the total sample. As there were significant differences in an ANOVA between several test parameters depending on the test site, not all variables were included in the total analysis.

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## CARA

**Table 7.2:** CARA-data - Varimax-rotated Factor structure of the neuropsychological tests/ Principal components analysis /Listwise deletion of missing values (N=69); loadings of marker variables are shaded

	Factors							Communality
	F1	F2	F3	F4	F5	F6	F7	
Active visual field: peripheral RT		,306			,776			,825
Active visual field: peripheral omissions					,908			,867
Active visual field: central RT	,349	,499		,260	,466		,268	,742
Active visual field: central omissions	,668	,236			,436			,761
Alertness: RT	,304					,711		,663
Alertness: STD	,549					,637		,751
Divided Attention: RT to tones	,568	,525		-,270				,710
Divided attention: omission of tones	,763					,293		,687
Divided Attention: RT to squares		,688					,295	,610
Divided Attention: omission of squares	,362			,451			,637	,747
Distractibility: RT when distracted		,662				,430	-,217	,726
Distractibility: errors with distraction		,219	,736		-,230			,653
Distractibility: omissions with distraction	,698	,221				,247		,665
Flexibility: RT	,497			,395				,454
Flexibility: errors	,400		,565			,354	,276	,719
Go/Nogo: RT		,436	-,555		,224	,436		,752
Go/Nogo: false alarms			,856					,807
Go/Nogo: omissions							,835	,732
Visual Scanning: detection time		,229		,857				,854
Visual Scanning: omissions	,625		,214	-,242			,247	,600
Visual Scanning: total search time				,874				,846
Executive Control: RT	,245	,700		,248	,228			,673
Executive control: false alarms			,659	,278	,305	,226	,268	,757
Executive control: omissions	,603	,286		,322	,294			,672

Explained variance: 71.97 %

The resulting factors can be termed as follows:

- F1: is mainly represented by omissions in executive and non-spatial attention tests and the Flexibility task (quality aspects of executive attention)
- F2: shows correlations with RTS of executive and non-spatial attention tests (speed aspects of executive attention)
- F3: is predominantly represented by false alarms of Go/nogo, Executive control and Distractibility (inhibitory control as a part of executive attention)
- F4: is associated with the speed of visual search in the test Visual Scanning (tempo-aspects of visuo-spatial attention when eye movements are involved)
- F5: correlates with the speed and quality of detecting targets in the peripheral visual field (visuo-spatial attention when eye movements are not involved)
- F6: is represented by both Alertness parameter (non-spatial attention)

- F7: is associated with omissions in Go/Nogo and the visual targets in Divided Attention. Thus, the ability to discriminate visual stimuli seems to be measured by this factor

## ***HIT***

**Table 7.3:** HIT-data - Varimax-rotated factor structure / Principal components analysis / Listwise deletion (N=91 subjects 4, 7, 24, 52, 54, 66, 100 had been excluded before) / Explained variance: 69.89 %; loadings of marker variables are shaded

	Factors								Communality
	F1	F2	F3	F4	F5	F6	F7	F8	
Active visual field: peripheral RT						,216		,811	,780
Active visual field: peripheral omissions				,662				,340	,603
Active visual field: central RT						,327	,691		,630
Active visual field: central omissions							,727		,578
Alertness: RT		,722				,383			,696
Alertness: STD		,823				,220	,207		,785
Divided Attention: RT to tones						,793			,761
Divided attention: omission of tones			,437	,563		-,250	,228		,641
Divided Attention: RT to squares			,411	,431	-,362	,370	,299		,743
Divided Attention: omission of squares	,645				,225				,572
Distractibility: RT when distracted		,705							,593
Distractibility: errors with distraction	,670								,539
Distractibility: omissions with distraction	,290	,484			,274		,532		,702
Flexibility: RT					,870				,812
Flexibility: errors	,368		,333	,371	,548			-,271	,797
Go/Nogo: RT	-,220	,262		,506		,613			,751
Go/Nogo: false alarms	,703	-,225				-,298			,708
Go/Nogo: omissions	,646								,522
Visual Scanning: detection time			,897						,848
Visual Scanning: omissions	,374		-,440	,619					,770
Visual Scanning: total search time			,844	-,210					,843
Executive Control: RT	-,557	,364			,231			,447	,735
Executive control: false alarms	,557			,301			-,258	-,391	,700
Executive control: omissions		,323			,628	-,305		,211	,666

The 8 factors can be conceptualized as

- F1: Inhibitory control (Executive attention)
- F2: non spatial attention
- F3: speed of visual search (visuo-spatial attention with eye movements)
- F4: quality of visuo-spatial attention (see fig. 1: the HIT subjects showed quite a lot omissions in Active Visual Field and Visual Scanning)
- F5: executive attention
- F6: non-spatial attention
- F7: focused attention (see fig. 1: especially with central targets the HIT subjects showed a lot of omissions; presumably this is an artificial factor resulting from comprehension problems of the subjects performing this test)

- F8: Visuo-spatial attention (when no eye movements are involved)

### VTI

**Table 7.4:** VTI data - Varimax-rotated Factor structure / Principal components analysis / Listwise deletion of missing values (N=29) / Explained variance: 79.82 %; loadings of marker variables are shaded.

	Factors							Communality
	F1	F2	F3	F4	F5	F6	F7	
Active visual field: peripheral RT	,276	,844			-,235			,881
Active visual field: peripheral omissions		,782			,236	,205	-,204	,772
Active visual field: central RT	,603	,425	,310			,297		,780
Active visual field: central omissions			,906					,911
Alertness: RT	,718	,370		,237				,749
Alertness: STD	,800	,232		,217				,785
Divided Attention: RT to tones	,801					,210		,706
Divided attention: omission of tones	,853							,808
Divided Attention: RT to squares	,546					,524		,623
Divided Attention: omission of squares	,379			,830				,872
Distractibility: RT when distracted	,860	,200						,832
Distractibility: errors with distraction					,861			,816
Distractibility: omissions with distraction	,802	,285						,731
Flexibility: RT	,871		,260		,216		,215	,941
Flexibility: errors	,672			,216			,580	,873
Go/Nogo: RT	,740			-,225		-,338		,727
Go/Nogo: false alarms							,855	,806
Go/Nogo: omissions		,205			,730	-,337		,721
Visual Scanning: detection time	,832		,307					,862
Visual Scanning: omissions				,257		,764	,232	,766
Visual Scanning: total search time	,839		,273				-,227	,855
Executive Control: RT	,778			-,424				,854
Executive control: false alarms				,774				,685
Executive control: omissions	,343		,791					,801

Due to listwise deletion of missing data the sample was reduced to N=29. Only these subjects showed complete data sets with respect to the used TAP-M variables. Thus, one has to be cautious concerning the interpretation of the factor structure because the numerical relation between the number of variables and number of subjects is recommended to be 1:3, which is not the case here.

The factors can be interpreted as follows:

- F1: a factor being represented by all RTs (with the exception of the peripheral RTs of Active Visual Field), errors of Flexibility and omissions of Divided Attention (tones) and Distractibility. A clearcut interpretation is not possible.
- F2: visuo-spatial attention (independent of eye movements)
- F3: Executive attention (omissions of central stimuli in Active Visual Field; omissions in Executive Control)
- F4: No clearcut interpretation possible

- F5: No clearcut interpretation possible
- F6: Visuo-spatial attention (with eye movements)
- F7: Inhibitory control (Executive attention)

### *Total sample*

Following the above mentioned suggestions, the omissions of Active Visual Field and Visual Scanning and the errors and omissions of Executive Control are excluded from the subsequent multivariate statistical analyses based on the total sample.

**Table 7.5:** Total sample - Varimax-rotated Factor structure / Principal components analysis / Listwise deletion of missing values (N=189) / Explained variance: 56.92 %; loadings of marker variables are shaded.

	Factors					Communality
	F1	F2	F3	F4	F5	
Active visual field: peripheral RT			,232	,749		,630
Active visual field: central RT	,360			,504	,248	,462
Alertness: RT	,598			,445		,562
Alertness: STD	,718			,355		,682
Divided Attention: RT to tones	,431	,210	-,422		,276	,484
Divided attention: omission of tones				,287	,663	,525
Divided Attention: RT to squares		,467		,377		,406
Divided Attention: omission of squares	,325	,221	,456		,363	,495
Distractibility: RT when distracted	,646					,470
Distractibility: errors with distraction			,738			,577
Distractibility: omissions with distraction	,584				,509	,609
Flexibility: RT		,215			,611	,430
Flexibility: errors			,318		,714	,652
Go/Nogo: RT	,244		-,343	,582		,526
Go/Nogo: false alarms			,768			,675
Go/Nogo: omissions	,356		,480			,416
Visual Scanning: detection time		,897			,232	,877
Visual Scanning: total search time		,891				,819
Executive Control: RT		,297	-,270	,582		,522

The extracted factors are interpreted as follows:

- F1: Non-spatial attention
- F2: Visuo-spatial attention (with eye movements)
- F3: Inhibitory control; executive attention
- F4: Visuo-spatial attention (independent of eye movements) and focused attention
- F5: Executive Attention

### 7.2.1 Already existing TAP/TAP-K subtests

These data have been collected in earlier studies and are based on the normative data presented in chapter 6.3.3.

#### 7.2.1.1 PC-Factor Analysis I/ 20-90 years / N=160

**Table 7.6:** Principal components analysis / Extraction according Eigenwert criterion / Varimax rotation / listwise exclusion of missing values / age 20-90 years (N=160).

	<i>Factor</i>			<i>Commulativity</i>
	1	2	3	
D1: Median RT	,795			,715
D1: Omissions	,506		,409	,429
D2: Median RT		,868		,761
D2: False alarms			,905	,822
D3: False alarms – total test			,839	,713
D3: Median RT - squares	,784			,680
D3: omissions - squares	,801			,653
D3: Median RT - tones		,892		,804
D3: omissions - tones		,416	,320	,348

D1: Divided Attention/Condition 1 (single task – squares); D2: Divided Attention/Condition 2 (single task – tones);  
D3: Divided Attention/Condition 3 (dual task – squares and tones);

The extracted factors can be interpreted as:

- ▶ **Factor 1:** Selective visual attention / detection of visual stimulus configurations
- ▶ **Factor 2:** Selective auditory attention
- ▶ **Factor 3:** Divided Attention, represented by the omissions and false alarms in the dual task situation

### 7.2.1.2 PC-Factor Analysis II/ 20-90 years / N=68

**Table 7.7:** Principal components analysis / Extraction according Eigen value criterion / Varimax rotation / listwise exclusion of missing values / age 20-90 years (N=68).

	<i>Factor</i>					<i>Communality</i>
	1	2	3	4	5	
AL: Median RT; Trials without warning tone	,937					,908
AL: Stdev RT; Trials without warning tone	,780				,342	,767
AL: Median RT; Trials with warning tone	,852				-,354	,882
AL: Index of phasic alertness					,866	,821
D3: False alarms – whole test		,890				,797
D3: Median RT - squares			,375		,402	,380
D3: omissions – squares	,319			,619		,526
D3: Median RT – tones		,875				,796
D3: omissions – tones		,885				,786
IK: Median RT; all trials	,312		,740			,699
IK: False reactions; all trials	-,342				,511	,497
WV3: Median RT; all trials with change of hand			,879			,877
WV3: False reactions; all trials with change of hand				,748		,569
WV3: Median RT; all trials without change of hand			,905			,908
WV3: False reactions; all trials without change of hand				,795		,702

AL: Alertness (in an extended version compared to the AGILE subtest); D3: Divided Attention/condition 3 – dual task/squares and tones; IK: Incompatibility (not included in the AGILE test battery); WV3: Flexibility/letters and numbers.

The extracted factors can be interpreted as:

- ▶ Factor 1: Overall activation level (tonic alertness)
- ▶ Factor 2: Selective auditory attention
- ▶ Factor 3: Response selection (high loadings of the choice reaction tasks)
- ▶ Factor 4: Selective visual attention and shifting of the attentional focus
- ▶ Factor 5: Phasic Alertness.

## 7.3 Criterion validity with respect to driving ability

### 7.3.1 Attention and self-assessment of driving behaviour

In the above mentioned “BASEL” study, 90% of the participants returned the questionnaire (N=666). 265 of them had taken part before in a detailed neuropsychological investigation and were considered not to be demented. The attention tests being used enabled to measure focused and divided attention, alertness and the super ordinate flexible, executive control of attention. As main results the following are highlighted:

- No significant correlation was found between participation in an accident and attentional parameters. This leads to the conclusion that situative factors are more important for the occurrence of an accident than general attentional performance.
- Correlations were found between the questionnaire of current physical well-being and flexible as well as focussed attention: Median reaction times of the test “Flexibility” showed a significant correlation ( $p=0.000$ ) with the questionnaire subscales „alertness and concentration” ( $r=0.3116$ ), „satisfaction with own body” ( $r=0.2235$ ), as well as „vitality“ ( $r=0.2146$ ). Omissions of the test “Focussed attention” also showed significant correlations ( $p=0.000$ ) with the subscale „vitality“.
- A significant positive correlation between the median reaction time in the test TAP-Flexibility (= flexible, executive control of attention) and the number of reported compensatory driving strategies (ANOVA;  $F=2,672$ ;  $df=8$ ;  $p=0.009$ ) (see model of Michon, 1971).
- A significant effect of the flexible control of attention and focused attention (median reaction times in the test “TAP-Flexibility”) on the subjective feeling of safety (ANOVA;  $F=11,293$ ;  $df=3$ ;  $p=0.000$ ).

### 7.3.2 Determinants of driving after stroke

Correlation coefficients and comparisons between groups of the BIVV/CARA study described above under 7.1.3 revealed that most variables had significant individual relationships with the team decision and performance on the road test, as can be seen in Table 7.. Several TAP/TAP-K subtests were used as predictors (divided attention, flexibility, incompatibility, visual scanning, visual field, neglect).

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**Table 7.8:** Correlation coefficients between predictor variables and the final group decision to drive and the on the road test (from Akinwuntan et al., 2002).

Predictor variables	N	Final group decision		Level of significance	On the road driving test		Level of significance
		$r_s$	C		$r_s$	C	
General data							
Age	104	-0.31		**	-0.34		***
Sex	104		0.17	NS		0.09	NS
Side of lesion	104		0.10	NS		0.23	*
Onset-examination interval	104	-0.36		***	-0.33		***
Driving experience	104	-0.32		***	-0.28		**
Visual field	104	-0.32		***	-0.26		**
Epilepsy	104	-0.24		*	-0.13		NS
Aphasia	104	-0.17		NS	-0.29		**
Visual tests							
Acuity of the left eye	104	0.37		***	0.32		***
Acuity of the right eye	104	0.34		***	0.40		***
Acuity of the left and right eye	104	0.35		***	0.44		***
Stereoscopy	104	0.29		**	0.21		*
Kinetic vision	104	0.43		***	0.27		**
Neuropsychological tests							
Figure of rey	99	0.42		***	0.48		***
Useful field of view	99	-0.43		***	-0.38		***
Divided attention	84						
Correct response		0.40		***	0.39		***
Median visual reaction time		-0.15		NS	-0.07		NS
Flexibility	42						
Median reaction time		-0.09		NS	-0.28		NS
Error		-0.24		NS	-0.41		**
Scanning	93						
Mean reaction time		-0.41		***	-0.40		***
Omissions with target		-0.18		NS	-0.27		**
Incompatibility	74						
Standard deviation reaction time		-0.28		*	-0.26		*
Difference in error		-0.12		NS	-0.24		*
Visual field	100						
Median reaction time		-0.33		***	-0.25		*
Absolute difference in reaction time		-0.23		*	-0.28		**
Absolute difference in omissions		-0.26		**	-0.14		NS
Visual neglect	101						
Absolute difference in reaction time		-0.43		***	-0.38		***
Absolute difference in omissions		-0.34		***	-0.21		*
Driving test							
On the road test	104	-0.67		***			

$r_s$ =Spearman rank correlation coefficient, C=Cramér coefficient

\* $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

Following logistic regression analysis, side of lesion, kinetic vision, TAP-visual scanning and the road test led to the best model in predicting the team decision (see Table 7.).

**Table 7.9:** Selected model by logistic regression in predicting the final group decision (from Akinwuntan et al., 2002).

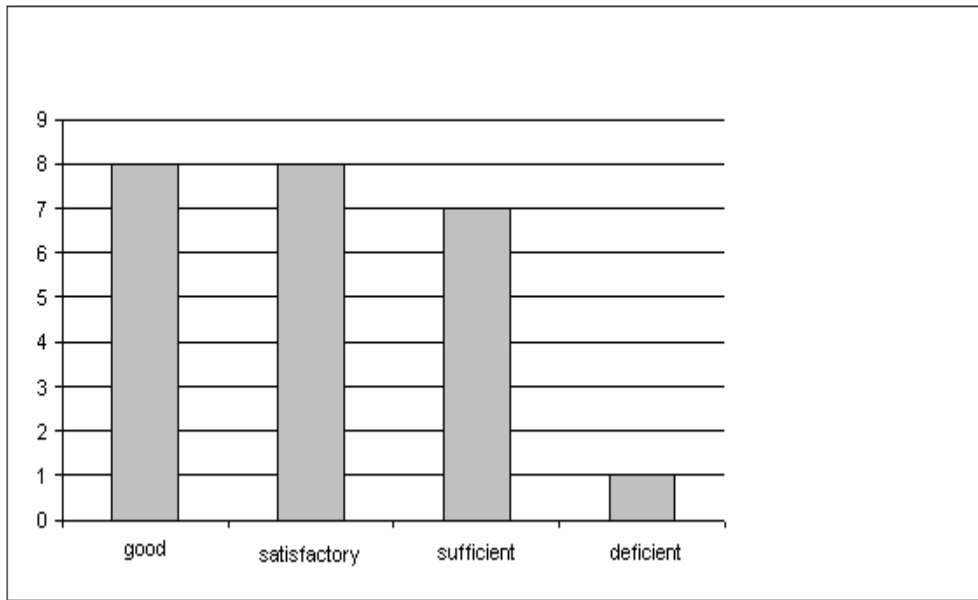
Variables	Parameter estimate	Standard error	Wald square	Chi- square	<i>P</i> - value	Odds ratio
Intercept 1	-3.16	1.58	3.99		0.05	
Intercept 2	0.45	1.52	0.09		0.77	
Side of lesion	-1.23	0.52	5.55		0.02	0.29
Kinetic vision	0.81	0.32	6.51		0.01	2.25
<b>TAP- Scanning</b>	-0.16	0.08	4.15		<b>0.04</b>	<b>0.85</b>
On the road test (5 units)	-0.14	0.03	28.55		0.00	2.02

N=93,  $R^2=0.53$

### 7.3.3 Driving skills assessment of aphasia patients

The following results are based on data collected cumulatively in the Aachen University Hospital (see 7.1.4 for description).

The judgement by driving instructors, based on the German school grades system, is distributed as shown below:

**Fig. 7.1:** Driving assessment – distribution of judgments in the given population

As predictors of driving behaviour, the following variables of TAP-Divided attention were applied:

**Table 7.10:** Correlations of TAP-Divided Attention and expert judgment

Variables	Spearman-range correlation with driving assessment performance	p (one-sided)
Standard deviation of reaction times - total	.345	.068
Median of reaction times - total	.180	.216
Omissions - total	.230	.165
Errors - total	.041	.432
Median of reaction times – visual trials	.244	.150
Omissions of critical visual trials	.184	.219
Median of reaction times – acoustic trials	.007	.488
Omissions of critical acoustic trials	.227	.168

Due to the distribution and rather ordinal scale quality of the variable „driving assessment judgement“, a Spearman- range correlation was computed between these parameters and the judgement.

As a comparison, Spearman range correlations with driving assessment of further test batteries used in the psychometrical assessment were computed. The results are shown in table 7.7.

**Table 7.11:** Correlations of several test batteries and expert judgment

Variables	Spearman-range correlation with driving assessment performance	p (one-sided)
LVT – raw data	-.075	.363
TVAT – Omissions	-.162	.230
TVAT - Errors	.007	.488
WDG – Correct responses	-.094	.331
WDG - Errors	-.219	.152

In summary, correlations between expert judgment and test performance are rather low, with TAP subtest “Divided Attention” showing slightly higher correlations compared to the other measures.

### 7.3.4 Correlations of the factor scores with AGILE on-road variables

In the AGILE study described in chapter 7.1.1, several different on-road protocols were conducted to assess driving abilities.

The TRIP (Test Ride for Investigating Practical fitness to drive) protocol (De Raedt 2000) consists of 67 single items which are computed into one global score (modified TRIP version, four-steps rating scale of driving skills: 1= insufficient, 2=doubtful, 3=adequate, 4=good). The protocol developed in the AGILE project (Sommer et al. 2003) consists of a basic abilities test (see table ...) and an optional assessment of different modules (non-spatial attention, visuo-spatial attention, executive attention). Both protocols (TRIP global score, AGILE basic and specific abilities) were completed in the pilot study.

**Table 7.12:** Basic driving abilities

Driving Task / Traffic Situation	Relevant Driving Skills
Starting and entering traffic	Starting up & merging into traffic flow.
Uncontrolled intersection (straight)	Preparation, visual scanning, interpretation of traffic situations, interaction with other road users.
Uncontrolled intersection (right turn)	Preparation, visual scanning, interpretation of traffic situations, interaction with other road users.
Uncontrolled intersection (left turn)	Preparation, visual scanning, interpretation of traffic situations, interaction with other road users.
Parking (‘seek parking space nearby’-instruction)	Visual scanning, compliance to instructions, interpretation of traffic situations, car manoeuvring etc.

Assessment of **non-spatial attention** combines traffic situations in which quick and correct reactions to traffic signals and regulations as well as appropriate reactions to other road users are crucial factors of driver behaviour (see table 7.13).

**Table 7.13:** Non-spatial attention

<b>Driving Task / Traffic Situation</b>	<b>Relevant Driving Skills</b>
Stopping at stop line (straight)	Compliance to traffic rules, visual scanning, starting up and merging into traffic flow.
Stopping at stop line (right)	Compliance to traffic rules, visual scanning, crossing traffic flow, starting up and merging into traffic flow.
Stopping at stop line (left)	Compliance to traffic rules, visual scanning, crossing traffic flow, starting up and merging into traffic flow.
Yielding at give way signs (straight)	Stopping for cars on priority lane, visual scanning, manoeuvring in traffic, attention to and interaction with other road users.
Yielding at give way signs (right)	Stopping for cars on priority lane, visual scanning, manoeuvring in traffic, attention to and interaction with other road users.
Yielding at give way signs (left)	Stopping for cars on priority lane, visual scanning, manoeuvring in traffic, attention to and interaction with other road users.
Signal controlled intersection (straight)	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Signal controlled intersection (right)	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Signal controlled intersection (left)	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Passing a zebra-crossing 1	Attention to and interaction with other road users, visual scanning, stopping for pedestrians.
Passing a zebra-crossing 2 (different location)	Attention to and interaction with other road users, visual scanning, stopping for pedestrians.

The assessment of **visuo-spatial attention** combines complex traffic situations with medium to high demands on visual attention.

**Table 7.14:** Visuo-spatial attention

<b>Driving Task / Traffic Situation</b>	<b>Relevant Driving Skills</b>
Signal controlled intersection (straight)	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Signal controlled intersection (right).	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Signal controlled intersection (left).	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Negotiating roundabout 1.	Spatial ability – lane keeping, visual scanning, interaction with other road users, merging in and out of traffic flow.
Negotiating roundabout 2 (different location).	Spatial ability – lane keeping, visual scanning, interaction with other road users, merging in and out of traffic flow.

<b>Driving Task / Traffic Situation</b>	<b>Relevant Driving Skills</b>
Passing a zebra-crossing 1.	Attention to and interaction with other road users, visual scanning, stopping for pedestrians.
Passing a zebra-crossing 2 (different location).	Attention to and interaction with other road users, visual scanning, stopping for pedestrians.
Information Processing 1: Passing a school next to the road - examiner asks driver to report verbally the relevant traffic elements in this situation.	Visual scanning, selective attention, situation awareness, interaction with other road users.
Information Processing 2: Driving in a visually loading area - examiner asks driver to report verbally the relevant traffic elements in this situation.	Visual scanning, selective attention, situation awareness, interaction with other road users.
Information Processing 3: Safety Awareness during intersection negotiation – examiner asks driver to report verbally the relevant traffic elements when proceeding through intersection (straight).	Visual scanning, selective attention, situation awareness, interaction with other road users.
Wayfinding / Navigation - ‘Take me to’ instruction, following signs to a destination.	Wayfinding in unfamiliar area, Interpretation of traffic signs, selective attention, visual scanning, situation awareness, interaction with other road users.

The third module of the specific assessment, **executive attention**, combines traffic situations requiring multi-tasking and flexible shifts of the attentional focus.

**Table 7.15:** Executive attention

<b>Traffic Situation</b>	<b>Relevant Driving Skills</b>
Passing through signal controlled intersection, (right turn).	Stopping for red lights and passing through green, visual scanning, attention to and interaction with other road users.
Passing through signal controlled intersection (left turn).	Stopping for red lights and passing through green, crossing traffic stream, visual scanning, attention to and interaction with other road users.
Right turn in signal controlled intersection, with pedestrians crossing after turn.	Preparation for unexpected events, visual scanning, interaction with pedestrians, flexibility to switch between driving tasks.
Adding 3s from 0 to 60 during easy driving task (straight road, low traffic density).	Prioritisation of easy primary driving task in a dual task condition.
Adding 3s from 0 to 60 during demanding driving task (curvy road, dense traffic).	Prioritisation of demanding primary driving task in a dual task condition.
Lane change from right lane to left lane before left turn.	Planning and executive control of driver behaviour, switching flexibly between driving tasks.
Lane change from left lane to right lane before right turn.	Planning and executive control of driver behaviour, switching flexibly between driving tasks.
Information Processing 1: Passing a school next to the road - examiner asks driver to report verbally the relevant traffic elements in this situation.	Interpretation of traffic signs, hazard recognition, visual scanning, situation awareness, interaction with other road users.
Information Processing 2: Passing a playground next to the road - examiner asks driver to report verbally the relevant traffic elements in this situation.	Interpretation of traffic signs, hazard recognition, visual scanning, situation awareness, interaction with other road users.
Following prospective navigation instructions of the examiner (e.g. turn right at the third signal-	Planning and executive control of driver behaviour, working memory, prospective memory.

Traffic Situation	Relevant Driving Skills
controlled intersection ahead).	
Wayfinding - 'Take me to' instruction, following signs to a destination.	Interpretation of traffic signs, selective attention, visual scanning, situation awareness, interaction with other road users.

Judgment is based on a two-item scale: satisfactory/not satisfactory. For any of the four assessment criteria of the AGILE protocol, a maximum score is conducted. The resulting ratio of single participant judgment and maximum score derives an index on the base of which a threefold decision is made: (a) fit to drive, (b) fit to drive with restrictions, and (c) unfit to drive. These results were correlated with TAP-M scores as well as factors from the factor analysis described in 7.2.1.

Table 7.8 shows the correlations of the factor scores from the principle component analysis described above. These results are based on the total AGILE sample.

**Table 7.16:** Total sample – Rank-order correlations between the 6 factors underlying TAP-M and pre-screening performance and the main on-road variables.

Factor	Spearman-Rho	TRIP Global score	AGILE on-road - basic skills	AGILE on-road - non-spatial attention	AGILE on-road - visuo-spatial attention	AGILE on-road - executive attention
F1	Coefficient	-,123	-,093	-,160(*)	-,102	-,085
	P (two-sided)	,100	,205	,029	,164	,247
F2	Coefficient	-,163(*)	-,144(*)	-,257(**)	-,258(**)	-,214(**)
	P (two-sided)	,029	,049	,000	,000	,003
F3	Coefficient	,236(**)	-,072	,098	,069	,063
	P (two-sided)	,001	,329	,183	,352	,392
F4	Coefficient	,151(*)	,131	,246(**)	,165(*)	,195(**)
	P (two-sided)	,042	,074	,001	,024	,007
F5	Coefficient	-,034	-,223(**)	-,068	-,094	-,115
	P (two-sided)	,647	,002	,356	,200	,118

\* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Results can be summarized as follows:

- Factor 1 (non-spatial attention) correlates with AGILE non-spatial attention
- Factor 2 (visuo-spatial attention with eye movements) has the highest correlations with all AGILE on-road dimensions and somewhat lower with the TRIP global score
- Factor 3 (inhibitory control; executive attention) is only associated with the TRIP global score
- Factor 4 (visuo-spatial attention without eye movements and focused attention) is also significantly correlated with the three attentional AGILE on-road dimensions
- Factor 5 (executive attention) correlates significantly with AGILE basic skills

**Table 7.17:** Rank-order correlations with the main TAP-M and the on-road variables; \* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Test parameter	Spearman-Rho	TRIP Global score	AGILE on- road - basic skills	AGILE on- road - non- spatial attention	AGILE on- road - visuo- spatial attention	AGILE on road - executive attention
Active visual field: peripheral RT	Coefficient P (two-sided)	,052 ,459	,026 ,711	,155(*) ,025	,090 ,192	,080 ,245
Active visual field: central RT	Coefficient P (two-sided)	,148(*) ,034	-,046 ,507	,134 ,053	,096 ,164	,107 ,122
Alertness: RT	Coefficient P (two-sided)	,051 ,469	,014 ,841	,022 ,748	,011 ,873	,041 ,553
Alertness:SD	Coefficient P (two-sided)	,079 ,263	-,034 ,628	-,009 ,899	-,009 ,899	,000 ,997
Divided Attention: RT to tones	Coefficient P (two-sided)	-,348(**) ,000	-,161(*) ,022	-,261(**) ,000	-,244(**) ,000	-,225(**) ,001
Divided Attention: omission of tones	Coefficient P (two-sided)	-,018 ,801	-,112 ,110	-,028 ,698	-,052 ,458	-,062 ,383
Divided Attention: RT to squares	Coefficient P (two-sided)	-,221(**) ,002	-,111 ,116	-,162(*) ,022	-,185(**) ,008	-,157(*) ,026
Divided Attention: omission of squares	Coefficient P (two-sided)	-,061 ,394	-,294(**) ,000	-,145(*) ,040	-,165(*) ,019	-,163(*) ,021
Distractibility: RT when distracted	Coefficient P (two-sided)	-,280(**) ,000	-,122 ,077	-,198(**) ,004	-,215(**) ,002	-,185(**) ,007
Distractibility: errors with distraction	Coefficient P (two-sided)	,166(*) ,018	-,095 ,167	,050 ,469	,045 ,512	,041 ,559
Distractibility: omissions with distraction	Coefficient P (two-sided)	-,015 ,836	-,108 ,120	-,032 ,646	-,038 ,588	-,044 ,525
Flexibility: RT	Coefficient P (two-sided)	,114 ,107	-,173(*) ,012	,022 ,755	-,017 ,807	-,026 ,714
Flexibility: errors	Coefficient P (two-sided)	,051 ,466	-,180(**) ,009	-,069 ,322	-,106 ,129	-,104 ,135
Go/Nogo: RT	Coefficient P (two-sided)	-,034 ,623	-,032 ,642	-,020 ,768	-,046 ,509	-,018 ,791
Go/Nogo: false alarms	Coefficient P (two-sided)	,178(*) ,010	-,001 ,994	,127 ,065	,106 ,123	,090 ,191
Go/Nogo: omissions	Coefficient P (two-sided)	,090 ,195	-,158(*) ,021	-,054 ,435	-,062 ,370	-,081 ,238
Visual Scanning: detection time	Coefficient P (two-sided)	-,145(*) ,041	-,260(**) ,000	-,300(**) ,000	-,315(**) ,000	-,298(**) ,000
Visual Scanning: total search time	Coefficient P (two-sided)	-,157(*) ,027	-,192(**) ,006	-,266(**) ,000	-,266(**) ,000	-,247(**) ,000
Executive Control: RT	Coefficient P (two-sided)	,014 ,847	,142(*) ,041	,110 ,116	,074 ,294	,125 ,073

Table xy shows rank order correlations between TAP parameters and on-road variables. Speed of visual search correlates highest with the on-road dimensions. Correlations are only modest with the TRIP but considerably higher with the AGILE on-road test. In addition, the flexibility test and Go/Nogo (omissions) are associated with AGILE basic skills. Further tests being correlated with the AGILE on-road dimensions are Divided Attention (RTs and omissions of squares), Distractibility (RTs) and Active visual field (peripheral RTs).

#### 7.3.4.1 CARA data

##### *Correlations between factor scores and on-road protocols*



Table 7.18 shows rank-order correlations between the factor score based on the above mentioned 7 factors and the TRIP global score and the 4 global AGILE on-road test scores.

**Table 7.18.:** Rank-order correlations between the factor score based on the above mentioned 7 factors and the TRIP global score and the 4 global AGILE on-road test scores

Factor	Spearman Rho	TRIP Total score	AGILE on-road - basic skills	AGILE on- road - non- spatial attention	AGILE on- road - visuo- spatial attention	AGILE on road - executive attention
F1	Coefficient P (two-sided)	-,252(*) ,038	-,126 ,306	-,141 ,251	-,154 ,211	-,171 ,163
F2	Coefficient P (two-sided)	-,214 ,080	-,009 ,940	-,023 ,850	-,065 ,599	-,026 ,833
F3	Coefficient P (two-sided)	-,264(*) ,030	-,160 ,194	-,196 ,110	-,167 ,172	-,166 ,176
F4	Coefficient P (two-sided)	-,248(*) ,042	-,394(**) ,001	-,376(**) ,002	-,424(**) ,000	-,390(**) ,001
F5	Coefficient P (two-sided)	-,182 ,138	-,195 ,112	-,175 ,155	-,184 ,134	-,180 ,142
F6	Coefficient P (two-sided)	,069 ,577	-,077 ,530	-,058 ,637	-,048 ,700	-,042 ,733
F7	Coefficient P (two-sided)	-,086 ,483	-,142 ,248	-,176 ,151	-,184 ,134	-,177 ,148

\* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Factor 4 (tempo-aspects of visuo-spatial attention, when eye movements are involved) correlated highest and significantly with all on-road parameters and expectedly the highest with AGILE on-road visuo-spatial attention. Interestingly, the correlations with the TRIP global score are somewhat lower indicating that this attentional aspect does not seem to be reflected as much in the TRIP items as it is in the AGILE on-road test. Only two additional significant correlations can be found, namely F1 (quality aspects of executive attention) and F3 (inhibitory control= each correlating significantly with the TRIP global score ( $p < .05$ )). F2 (speed aspects of executive attention) and F6 (non-spatial attention) do not seem to be associated with the AGILE on-road ratings.

### *Correlations between TAP-M parameters and on-road variables*

**Table 2.19:** CARA-data - Rank-order correlations between the main TAP-M and pre-screening test variables and the on-road measures

Test parameter	Spearman Rho	TRIP Total score	AGILE on-road - basic skills	AGILE on-road - non-spatial attention	AGILE on-road - visuo-spatial attention	AGILE on road - executive attention
Active visual field: peripheral RT	Coefficient P (two-sided)	-,433(**) ,000	-,396(**) ,001	-,396(**) ,001	-,429(**) ,000	-,405(**) ,000
Active visual field: peripheral omissions	Coefficient P (two-sided)	-,307(**) ,009	-,288(*) ,014	-,258(*) ,029	-,258(*) ,029	-,270(*) ,022
Active visual field: central RT	Coefficient P (two-sided)	-,254(*) ,032	-,205 ,084	-,232 ,050	-,264(*) ,025	-,226 ,056
Active visual field: central omissions	Coefficient P (two-sided)	-,257(*) ,029	-,239(*) ,043	-,207 ,082	-,267(*) ,023	-,240(*) ,042
Alertness: RT	Coefficient P (two-sided)	-,162 ,170	-,194 ,101	-,144 ,224	-,197 ,095	-,169 ,152
Alertness:SD	Coefficient P (two-sided)	-,132 ,265	-,244(*) ,037	-,193 ,101	-,193 ,102	-,201 ,087
Divided Attention: RT to tones	Coefficient P (two-sided)	-,204 ,088	,002 ,989	,011 ,929	-,010 ,934	-,002 ,986
Divided Attention: omission of tones	Coefficient P (two-sided)	-,275(*) ,020	-,216 ,071	-,253(*) ,033	-,283(*) ,017	-,259(*) ,029
Divided Attention: RT to squares	Coefficient P (two-sided)	-,230 ,055	-,119 ,327	-,128 ,290	-,176 ,146	-,140 ,247
Divided Attention: omission of squares	Coefficient P (two-sided)	-,294(*) ,013	-,403(**) ,000	-,389(**) ,001	-,423(**) ,000	-,411(**) ,000
Distractibility: RT when distracted	Coefficient P (two-sided)	-,198 ,093	-,201 ,089	-,155 ,191	-,191 ,105	-,170 ,150
Distractibility: errors with distraction	Coefficient P (two-sided)	-,218 ,063	-,208 ,077	-,229 ,051	-,201 ,088	-,208 ,078
Distractibility: omissions with distraction	Coefficient P (two-sided)	-,267(*) ,022	-,207 ,079	-,188 ,112	-,226 ,054	-,214 ,069
Flexibility: RT	Coefficient P (two-sided)	-,314(**) ,007	-,317(**) ,007	-,262(*) ,026	-,315(**) ,007	-,277(*) ,018
Flexibility: errors	Coefficient P (two-sided)	-,251(*) ,034	-,212 ,074	-,266(*) ,024	-,280(*) ,017	-,250(*) ,034
Go/Nogo: RT	Coefficient P (two-sided)	-,009 ,938	-,116 ,324	-,090 ,446	-,133 ,258	-,117 ,321
Go/Nogo: false alarms	Coefficient P (two-sided)	-,092 ,433	-,033 ,777	-,068 ,567	-,023 ,844	-,028 ,811
Go/Nogo: omissions	Coefficient P (two-sided)	-,138 ,242	-,184 ,117	-,261(*) ,024	-,231(*) ,048	-,219 ,060
Visual Scanning: detection time	Coefficient P (two-sided)	-,379(**) ,001	-,484(**) ,000	-,451(**) ,000	-,488(**) ,000	-,470(**) ,000

Visual Scanning: omissions	Coefficient	-,099	-,138	-,145	-,136	-,147
	P (two-sided)	,406	,249	,225	,256	,218
Visual Scanning: total search time	Coefficient	-,356(**)	-,424(**)	-,409(**)	-,445(**)	-,426(**)
	P (two-sided)	,002	,000	,000	,000	,000
Executive Control: RT	Coefficient	-,278(*)	-,180	-,197	-,284(*)	-,218
	P (two-sided)	,018	,130	,097	,016	,066
Executive Control: false alarms	Coefficient	-,234(*)	-,283(*)	-,280(*)	-,303(**)	-,289(*)
	P (two-sided)	,048	,016	,017	,010	,014
Executive Control: omissions	Coefficient	-,356(**)	-,230	-,251(*)	-,315(**)	-,267(*)
	P (two-sided)	,002	,052	,034	,007	,023

\* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Taken together, the RTs of Active Visual Field and Visual Scanning as well as Flexibility, Divided Attention (omissions of squares), Executive Control (errors and omissions) and Divided Attention (omissions of tones) correlate highest and significantly with the on-road parameters, Go/Nogo, Alertness and Distractibility do not seem to be substantially correlated with on-road parameters.

### 7.3.4.2 HIT data

#### *Correlations between factor scores and on-road protocols*

**Table 7.20:** HIT-data – Rank-order correlations between the 8 factor scores and the relevant on-road variables

Factor	Spearman-Rho	TRIP Global score	AGILE on-road - basic skills	AGILE on-road - non-spatial attention	AGILE on-road - visuo-spatial attention	AGILE on road - executive attention
F1	Coefficient	-,009	-,244(*)	-,170	-,232(*)	-,211(*)
	P (two-sided)	,935	,020	,108	,027	,045
F2	Coefficient	,061	,181	-,015	,162	,187
	P (two-sided)	,580	,085	,887	,125	,075
F3	Coefficient	,174	,145	,045	-,080	,026
	P (two-sided)	,112	,171	,670	,451	,807
F4	Coefficient	-,221(*)	-,257(*)	-,165	-,152	-,179
	P (two-sided)	,042	,014	,118	,151	,090
F5	Coefficient	-,032	-,088	-,028	-,054	-,105
	P (two-sided)	,772	,405	,790	,614	,323
F6	Coefficient	-,152	-,138	-,141	-,259(*)	-,101
	P (two-sided)	,165	,191	,183	,013	,340
F7	Coefficient	-,153	-,168	-,015	-,115	-,168
	P (two-sided)	,162	,112	,888	,278	,112
F8	Coefficient	,057	,009	,222(*)	,116	,113
	P (two-sided)	,607	,934	,035	,273	,286

\* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Table 7.20 demonstrates only few, rather low, significant correlations:

- F1 (inhibitory control; executive attention) correlates with AGILE basic skills, visuo-spatial attention and executive attention.

- F4 (quality of visuo-spatial attention) is associated with the TRIP global score and AGILE on-road basic skills
- F6 (non-spatial attention) correlates significantly with AGILE visuo-spatial attention
- F8 (visuo-spatial attention independent of eye movements) is linked to AGILE non-spatial attention

In sum, the low correlations (even the significant ones) suggest a very weak relationship between the main factors underlying neuropsychological performance and on-road behaviour.

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### *Correlations between TAP-M parameters and on-road variables*

**Table 7.21** HIT-data - Rank-order correlations between the main TAP-M and pre-screening test variables and the on-road measures; \* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Test parameter	Spearman-Rho	TRIP Total score	AGILE on- road - basic skills	AGILE on- road - non- spatial attention	AGILE on- road - visuo- spatial attention	AGILE on road - executive attention
Active visual field: peripheral RT	Coefficient P (two-sided)	-,003 ,980	-,101 ,338	,071 ,500	-,057 ,589	-,087 ,407
Active visual field: peripheral omissions	Coefficient P (two-sided)	-,180 ,096	-,110 ,293	-,187 ,073	-,058 ,583	-,028 ,788
Active visual field: central RT	Coefficient P (two-sided)	-,178 ,099	-,272(**) ,008	-,170 ,103	-,241(*) ,020	-,192 ,065
Active visual field: central omissions	Coefficient P (two-sided)	-,062 ,570	-,079 ,452	-,051 ,624	-,083 ,427	-,142 ,174
Alertness: RT	Coefficient P (two-sided)	-,009 ,931	,064 ,542	,005 ,960	,046 ,659	,099 ,344
Alertness:SD	Coefficient P (two-sided)	,020 ,857	,067 ,521	-,052 ,623	-,037 ,724	,012 ,906
Divided Attention: RT to tones	Coefficient P (two-sided)	-,162 ,134	-,061 ,559	-,074 ,481	-,121 ,249	-,010 ,924
Divided Attention: omission of tones	Coefficient P (two-sided)	,013 ,902	-,091 ,383	,042 ,692	-,039 ,713	-,114 ,278
Divided Attention: RT to squares	Coefficient P (two-sided)	-,139 ,198	-,043 ,681	-,128 ,221	-,201 ,054	-,101 ,337
Divided Attention: omission of squares	Coefficient P (two-sided)	-,185 ,086	-,300(**) ,003	-,155 ,137	-,250(*) ,016	-,215(*) ,038
Distractibility: RT when distracted	Coefficient P (two-sided)	-,200 ,064	-,066 ,531	,016 ,881	-,052 ,623	-,020 ,850
Distractibility: errors with distraction	Coefficient P (two-sided)	,199 ,065	-,043 ,679	-,034 ,744	-,107 ,309	-,051 ,627
Distractibility: omissions with distraction	Coefficient P (two-sided)	,023 ,832	-,072 ,493	-,023 ,830	-,026 ,806	-,027 ,797
Flexibility: RT	Coefficient P (two-sided)	-,032 ,767	-,207(*) ,048	,008 ,941	-,162 ,122	-,201 ,055
Flexibility: errors	Coefficient P (two-sided)	-,074 ,497	-,235(*) ,024	-,260(*) ,012	-,344(**) ,001	-,306(**) ,003
Go/Nogo: RT	Coefficient P (two-sided)	-,150 ,167	-,157 ,133	-,089 ,394	-,117 ,263	-,056 ,595
Go/Nogo: false alarms	Coefficient P (two-sided)	,098 ,368	-,152 ,146	-,058 ,578	-,109 ,298	-,178 ,087
Go/Nogo: omissions	Coefficient P (two-sided)	,024 ,824	-,203 ,051	-,204 ,050	-,205(*) ,048	-,275(**) ,008
Visual Scanning: detection time	Coefficient P (two-sided)	,102 ,354	-,006 ,958	-,067 ,531	-,184 ,080	-,083 ,436
Visual Scanning: omissions	Coefficient P (two-sided)	-,311(**) ,004	-,353(**) ,001	-,200 ,057	-,253(*) ,015	-,305(**) ,003
Visual Scanning: total search time	Coefficient P (two-sided)	,144 ,189	,134 ,206	,060 ,572	-,027 ,799	,102 ,336
Executive Control: RT	Coefficient P (two-sided)	-,038 ,726	,162 ,120	,173 ,097	,141 ,177	,156 ,135
Executive Control: false alarms	Coefficient P (two-sided)	,019 ,865	-,075 ,476	-,134 ,202	-,141 ,179	-,136 ,194
Executive Control: omissions	Coefficient P (two-sided)	-,040 ,711	-,080 ,445	-,019 ,860	,031 ,771	-,035 ,743

Taken together, the test parameters correlating highest and significantly with the AGILE

on-road test scores are Flexibility (errors), Visual Scanning (omissions). Furthermore, the central RTs in Active Visual Field show associations with AGILE on-road basic skills and visuo-spatial attention. Divided Attention (omission of squares) correlates with all but non-spatial attention of the AGILE on-road scores. In addition, Go/Nogo (omission) correlates significantly with AGILE on-road executive attention.

### 7.3.4.3 HIT data

#### *Correlations between factor scores and on-road protocols*

**Table 7.22** VTI-data – Rank order correlations between TAP-M and pre-screening parameters and the main on-road variables

Factor	Spearman-Rho	TRIP global score	AGILE on-road - basic skills	AGILE on-road - non-spatial attention	AGILE on-road - visuo-spatial attention	AGILE on road - executive attention
F1	Coefficient	-,070	,360	,067	,164	,233
	P (two-sided)	,724	,060	,738	,415	,243
F2	Coefficient	-,213	-,402(*)	-,646(**)	-,437(*)	-,581(**)
	P (two-sided)	,276	,034	,000	,023	,001
F3	Coefficient	-,134	,053	-,208	-,191	-,231
	P (two-sided)	,497	,788	,297	,340	,245
F4	Coefficient	-,141	-,006	,096	,055	-,044
	P (two-sided)	,474	,975	,634	,784	,827
F5	Coefficient	-,220	-,460(*)	-,257	-,292	-,335
	P (two-sided)	,261	,014	,195	,139	,088
F6	Coefficient	,036	-,123	-,180	-,298	-,264
	P (two-sided)	,857	,532	,370	,130	,182
F7	Coefficient	-,218	,037	-,143	-,345	-,128
	P (two-sided)	,266	,851	,477	,078	,526

\* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Table 7.22 shows highly significant correlations between F2 (visuo-spatial attention independent of eye movements) and the on-road variables, especially non-spatial and executive attention. Furthermore F5 (Distractibility?, Inhibitory control?) correlates significantly with AGILE basic skills. Interestingly, no significant correlations between the TRIP global score and the 7 factors can be found.

### *Correlations between TAP-M parameters and on-road variables*

**Table 7.23:** VI-data - Rank-order correlations between the main TAP-M and pre-screening parameters and the on-road variables; \* =  $p < .05$  (2-sided); \*\* =  $p < .01$  (2-sided)

Test parameter	Spearman-Rho	TRIP Total score	AGILE on- road - basic skills	AGILE on- road - non- spatial attention	AGILE on- road - visuo- spatial attention	AGILE on road - executive attention
Active visual field: peripheral RT	Coefficient P (two-sided)	-,315(*) ,033	-,258 ,083	-,334(*) ,025	-,293 ,051	-,390(**) ,008
Active visual field: peripheral omissions	Coefficient P (two-sided)	-,152 ,314	-,220 ,142	-,302(*) ,044	-,094 ,539	-,279 ,063
Active visual field: central RT	Coefficient P (two-sided)	-,125 ,407	-,041 ,788	-,257 ,089	-,223 ,141	-,323(*) ,031
Active visual field: central omissions	Coefficient P (two-sided)	-,067 ,658	,003 ,982	-,269 ,074	-,190 ,212	-,280 ,062
Alertness: RT	Coefficient P (two-sided)	-,046 ,772	-,051 ,746	-,466(**) ,002	-,274 ,079	-,314(*) ,043
Alertness:SD	Coefficient P (two-sided)	-,002 ,990	-,054 ,733	-,323(*) ,037	-,218 ,165	-,262 ,094
Divided Attention: RT to tones	Coefficient P (two-sided)	-,027 ,871	,065 ,694	,222 ,181	,252 ,126	,169 ,311
Divided Attention: omission of tones	Coefficient P (two-sided)	-,319(*) ,048	,026 ,877	,046 ,783	-,006 ,970	,024 ,887
Divided Attention: RT to squares	Coefficient P (two-sided)	-,165 ,315	,098 ,554	-,092 ,581	-,082 ,624	-,145 ,384
Divided Attention: omission of squares	Coefficient P (two-sided)	-,055 ,740	,050 ,761	-,036 ,828	-,028 ,866	-,079 ,639
Distractibility: RT when distracted	Coefficient P (two-sided)	-,103 ,499	,136 ,372	-,047 ,761	,090 ,562	,142 ,358
Distractibility: errors with distraction	Coefficient P (two-sided)	-,192 ,207	-,175 ,249	-,064 ,679	-,099 ,522	-,165 ,286
Distractibility: omissions w. distraction	Coefficient P (two-sided)	-,202 ,183	-,065 ,672	-,144 ,352	-,013 ,934	-,113 ,466
Flexibility: RT	Coefficient P (two-sided)	-,106 ,490	,106 ,488	-,141 ,363	-,210 ,171	-,163 ,290
Flexibility: errors	Coefficient P (two-sided)	-,393(**) ,008	-,026 ,867	-,269 ,077	-,494(**) ,001	-,382(*) ,010
Go/Nogo: RT	Coefficient P (two-sided)	-,167 ,267	,142 ,347	-,083 ,589	-,036 ,814	-,027 ,859
Go/Nogo: false alarms	Coefficient P (two-sided)	-,141 ,350	,074 ,626	-,029 ,848	-,229 ,131	-,069 ,652
Go/Nogo: omissions	Coefficient P (two-sided)	-,295(*) ,046	-,372(*) ,011	-,385(**) ,009	-,404(**) ,006	-,384(**) ,009
Visual Scanning: detection time	Coefficient P (two-sided)	-,069 ,659	,115 ,462	-,065 ,682	,064 ,687	-,059 ,710
Visual Scanning: omissions	Coefficient P (two-sided)	-,017 ,914	-,067 ,671	-,194 ,219	-,373(*) ,015	-,305(*) ,050
Visual Scanning: total search time	Coefficient P (two-sided)	-,093 ,553	,136 ,386	-,006 ,971	,128 ,419	,001 ,994
Executive Control: RT	Coefficient P (two-sided)	-,061 ,702	,331(*) ,032	,088 ,583	,100 ,535	,233 ,143
Executive Control: false alarms	Coefficient P (two-sided)	-,087 ,584	-,198 ,209	-,320(*) ,041	-,277 ,079	-,352(*) ,024
Executive Control: omissions	Coefficient P (two-sided)	-,149 ,345	,079 ,617	-,084 ,602	-,075 ,643	-,060 ,710

Taken together, Active Visual Field (peripheral RTs), Flexibility (errors), Go/Nogo (omissions), Visual Scanning (omissions), Executive control (false alarms), and Alertness (RT) correlate highest with the on-road behaviour. Interestingly, each of these TAP-M parameters seems to be mainly linked to only a subset of on-road dimensions, partly going into the desired direction (Visual Scanning – AGILE visuo-spatial

Attention; Executive Control – AGILE executive Attention; Alertness – AGILE-non-spatial attention).

## 7.4 Validity of the Executive Attention subtest as a pre-screening instrument

Within the AGILE project, decision about a participant's driving skills was made in a process containing several different steps. In a pre-screening, participants were divided into a “fit to drive” group and a “referral to further examination” group. Table xxx shows the tests used in the pre-screening procedure.

**Table 7.24** Component tests included in the AGILE screening battery (+ the relevant variables that can be collected as results) and the cognitive functions they tap.

Screening test battery	Integrated functions, measurements
Trail Making Test A	Basic attention, visual scanning/search, visuo-motor tracking, psychomotor speed, eye-hand co-ordination speed, handiness, information processing speed.
MMSE	Orientation in time and space, recall, memory, working memory, attention, object naming, ability to follow verbal and written commands, spontaneous sentence writing, visuo-spatial and -constructive functions
Executive Control	Working memory, Divided attention, Mental flexibility, Selective attention, Response inhibition, Choice reaction
IADL	Behavioural changes, Tiredness, Reduced speed <sup>1</sup>

The **Trail Making Test (TMT)** (Reitan, 1955) is an easily administered P&P test of visual conceptual and visuo-motor tracking (Lezak, 1995). In the part A of the test, the subject is asked to draw lines to connect consecutively numbered circles. The subject is instructed to do the task as fast as possible without lifting the pencil from the paper. The test taps complex visual scanning with a motor component. TMT-A has been shown to be sensitive to age.

The **Mini Mental State Examination** (Folstein, Folstein & McHugh, 1975) is a short and quick evaluation of general cognitive functioning, particularly used in the elderly as a screening instrument for dementia. The evaluation consists of tests of orientation in time and space, memory, attention, object naming, ability to follow verbal and written commands, spontaneous sentence writing, and ability to copy a complex figure. Scores range from 0 to 30, with lower scores indicating stronger cognitive impairment.

The **questionnaire of Instrumental Activities of Daily Living (IADL)** from (Avlund, Schultz-Larsen & Kreiner, 1993) has also been included. It is composed of 14 items, and according to the authors, the scale achieves sufficient content validity, since it measures a wide range of activities relevant to elderly people, and it is applicable to both men and women. The scale also allows a distinction between what elderly are capable of doing and what they actually do. Because the scale includes a larger number of activities of daily living than most scales do, it is postulated it allows the differentiation between different groups of elderly without known problems as well as

<sup>1</sup> IADL measures are no cognitive measures.



between different elderly populations according to various other health indicators. Three IADL indexes were computed (the 'not relevant' answers are not taken into consideration):

**Ability index** (questions "Are you able to..."):

Number of "Yes" answers/ (Number of "Yes" answers + Number of "No" answers)

**Tiredness index** (question about tiredness; only computed for the items where the ability question was answered with "Yes"):

Number of "No" answers/ (Number of "No" answers + Number of "Yes" answers)

**Reduced speed index** (questions about reduced speed; only computed for the items where the ability question was answered with "Yes"):

Number of "No" answers/ (Number of "No" answers + Number of "Yes" answers)

High indexes (maximum score = 1) indicate individuals with few limitations in their daily living and that activities neither make them more often tired nowadays or that they are more time consuming.

The following results are based on data from AGILE partner CARA.

A t-test and a Mann-Whitney-U-Test for parametric and nonparametric variables respectively was conducted to compare results in screening tests concerning the categories "fit to drive" and "further referral". Results are displayed below.

**Tabelle 7.25:** Results of the means comparison of "fit to drive" and "further referral" samples

	Fit to drive Mean (SD)	Further referral Mean (SD)	t/U	Significance (two-sided) p≤0.05* p≤0.01**
<b>IADL Ability</b>	0.97 (0.06)	0.90 (0.12)	373	**
<b>IADL Tiredness</b>	0.92 (0.08)	0.87 (0.13)	436	n.s.
<b>IADL Reduced Speed</b>	0.90 (0.09)	0.84 (0.13)	404.5	n.s.
<b>TMT-A</b>	55.59 (15.25)	77.22 (20.75)	-4.465	**
<b>Executive Control Median RT</b>	762.88 (167.59)	843.83 (197.20)	394.5	n.s.
<b>Executive Control SD</b>	210.92 (91.02)	265.91 (102.01)	363.5	*
<b>Executive Control Correct Responses total</b>	35.81 (5.79)	30.30 (9.30)	287.5	**
<b>Executive Control Errors total</b>	8.58 (7.72)	12.39 (9.06)	367.5	*
<b>Executive Control Omissions total</b>	3.67 (5.32)	7.39 (7.13)	337	**

Apart from Median reaction time, all comparisons between groups concerning "Executive Control" show significant differences.

Based on exploratory logistic regression, some variables were chosen to be especially valid for driving skills and integrated into a model of logistic regression. The following variables were integrated:

➤ TMT-A

(Wald=11,569, p=0,001),

- Executive Control (Errors) (Wald=1,314, p=0,252),
- IADL Ability (Wald=3,075, p=0,080)
- IADL Tiredness (Wald=4,210, p=0,040)

Table XY shows classification of participants based on the regression model.

**Tabelle 7.26:** Classification (Expert judgment vs. pre-screening results)

		Expert Judgment (Criterion)		% Correct decision
		Further referral	Fit to drive	
Pre-Screening result (Predictor)	Failed	17	7	87,5
	Passed	3	40	88
% Correct Decision		85	85	85

In this model, 7 subjects who failed the pre-screening were judged fit to drive, and 3 subjects who passed the pre-screening were referred for further assessment. Therefore, sensitivity (Referral to further assessment) is 85 %, and specificity (Correct decision “fit to drive”) is also 85%.

## 7.5 Conclusion for Validity

Factor analyses conducted with different samples show different, empirically distinct attentional functions assessed by TAP-M. All analyses found visuo-spatial components mainly represented by the subtests Active Visual Field, Visual Scanning, and Divided Attention/Visual condition. A factor “Executive Attention” tapping quality measures of the Flexibility and Executive Control subtests was also found in all analyses. A third factor can be identified as “general alertness” (Alertness, measures of reaction speed in other subtests). Intercorrelations between subtests are low, therefore a sufficient dimensionality of TAP-M subtests can be assumed.

Different studies found correlations of TAP-M parameters with driving skills criteria. There is, however, still a great need of suitable criteria for judgment of driving skills in an on-road test. The AGILE protocol containing several judgment dimensions can be seen as a first step to increasing standardization.

Preliminary analyses show that the „Executive Control“ subtest might be a valid pre-screening tool to distinct subjects fit to drive from those in need of an in-depth assessment. The potential use as a pre-screening instrument is under further examination.



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## Appendix A: Norm data

The following tables show the correction coefficients as well as normative values for the respective subtests. Normative corrections are performed automatically by the program (to be selected via “Options → Norms”). Therefore manual correction is not necessary. The correction coefficients were computed as described in chapter 4.2.1.

### Abbreviations:

SD=Standard deviation

MDN=Median

RT=Reaction times

M(trend)= Mean of trend corrected sample

M(dispen)= Mean of dispersion corrected sample

R<sup>2</sup>= Regression coefficient

PR=Percentile Rank

Omi.=Omissions

Co.= Column

corr.=Correlation

### A 1: Alertness

#### Trend Correction (Regression coefficients)

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>	Sex*Age
SD	38.551	0.120	20.786	3.910	0.260	0	0	0
MDN	232.968	0.139	207.183	0	0	0	0	0.395

#### Dispersion Correction (Regression coefficients)

Parameter	M(dispen)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>	Sex*Age
SD	11.335	0.035	7.620	0	7.800E-02	0	0	0
MDN	26.911	0.063	10.083	3.957	0.235	0	0	0

**Norms**

SD	MDN	T Value	PR
360,0	675,8	20	0
317,7	628,3	21	0
293,6	595,7	22	0
284,9	573,4	23	0
269,6	549,6	24	0
238,4	538,4	25	1
221,1	534,3	26	1
213,9	524,2	27	1
196,9	468,7	28	1
169,9	429,2	29	2
165,0	413,7	30	2
160,5	400,8	31	3
141,6	364,4	32	4
123,5	345,5	33	4
113,2	338,7	34	5
106,4	327,7	35	7
99,9	316,5	36	8
93,4	309,0	37	10
88,0	290,2	38	12
79,9	280,9	39	14
72,9	267,9	40	16
65,7	260,5	41	18
63,0	250,7	42	21
59,7	243,1	43	24
55,3	238,4	44	27
52,0	234,4	45	31
48,6	230,0	46	34
46,0	225,3	47	38
43,4	219,3	48	42
42,0	212,4	49	46
40,0	206,9	50	50
37,7	202,8	51	54
35,9	196,4	52	58
34,5	191,9	53	62
32,5	187,5	54	66
31,0	183,5	55	69
29,9	180,6	56	73
28,4	177,3	57	76
26,5	172,6	58	79
25,0	170,7	59	82
24,1	167,2	60	84
23,2	164,6	62	86
21,1	161,8	62	88
20,3	159,2	63	90
19,2	157,4	64	92
18,2	155,2	65	93
17,5	153,8	66	95
16,1	151,6	67	96
15,7	147,5	68	96
15,2	145,9	69	97
14,1	144,4	70	98
13,2	141,7	71	98
11,5	137,0	72	99
9,4	136,3	73	99
8,5	134,3	74	99
7,7	132,3	75	99

SD	MDN	T Value	PR
7,4	130,8	76	100
7,3	122,2	77	100
7,3	116,7	78	100
7,3	113,5	79	100
7,3	113,5	80	100

**This table is based on the age corrected data!**

## A 2: Flexibility

### A 2.1 Flexibility/Number

- *No correction of norm values necessary* –

#### Norms

SD	MDN	Error	T Value	PR
154,6	668,1	3,0	20	0
154,5	667,3	3,0	21	0
154,4	666,2	3,0	22	0
154,2	664,9	3,0	23	0
154,0	663,2	3,0	24	0
153,8	661,0	3,0	25	1
153,4	658,2	3,0	26	1
153,0	654,5	3,0	27	1
152,5	649,9	3,0	28	1
151,8	644,2	3,0	29	2
151,0	637,1	3,0	30	2
150,0	628,6	3,0	31	3
148,8	618,2	3,0	32	4
147,4	605,6	3,0	33	4
144,4	593,8	3,0	34	5
135,4	592,5	3,0	35	7
124,9	591,1	3,0	36	8
112,8	589,4	3,0	37	10
100,7	581,3	2,8	38	12
88,7	566,2	2,4	39	14
75,7	549,4	2,0	40	16
75,4	536,1	2,0	41	18
75,1	521,9	2,0	42	21
74,7	520,5	1,4	43	24
73,2	511,7	1,0	44	27
69,2	487,6	1,0	45	31
68,1	479,5	1,0	46	34
66,6	474,3	1,0	47	38
63,1	466,6	1,0	48	42
62,6	461,7	1,0	49	46
62,1	456,5	1,0	50	50
59,5	445,1	1,0	51	54
53,1	421,9	1,0	52	58
50,2	413,5	0,3	53	62
48,8	406,2	0,0	54	66

SD	MDN	Error	T Value	PR
48,1	398,9	0,0	55	69
47,7	388,8	0,0	56	73
47,0	384,9	0,0	57	76
46,3	384,0	0,0	58	79
44,9	374,0	0,0	59	82
43,6	364,3	0,0	60	84
42,7	363,2	0,0	62	86
41,8	362,4	0,0	62	88
41,2	361,2	0,0	63	90
40,8	359,7	0,0	64	92
40,4	358,3	0,0	65	93
40,0	357,2	0,0	66	95
40,0	357,0	0,0	67	96
40,0	357,0	0,0	68	96
40,0	357,0	0,0	69	97
40,0	357,0	0,0	70	98
40,0	357,0	0,0	71	98
40,0	357,0	0,0	72	99
40,0	357,0	0,0	73	99
40,0	357,0	0,0	74	99
40,0	357,0	0,0	75	99
40,0	357,0	0,0	76	100
40,0	357,0	0,0	77	100
40,0	357,0	0,0	78	100
40,0	357,0	0,0	79	100
40,0	357,0	0,0	80	100

## A 2.2 Flexibility/Alternating

### Trend Correction (Regression coefficients)

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>	Sex*Age
SD	236.9080	0.185	161.682	0	0	0	5.882E-04	0
MDN	802.5475	0.276	391.576	0	10.637	0	0	-1.789
Error	4.13	0.016	5.659	-1.413	0	0	0	0

**Dispersion Correction (Regression coefficients)**

Parameter	M(dis)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>
SD	81.4352	0.115	48.139	0	0	0	2.603E-04
MDN	156.5760	0.07	111.258	0	0	0	3.515E-04
Error	0	0	0	0	0	0	0

**Norms**

SD	MDN	Fehler	T Value	PR
1886,9	5631,1	53,4	20	0
1881,5	5065,4	53,0	21	0
1875,3	4405,5	52,6	22	0
1836,2	3911,6	52,1	23	0
1733,1	3833,4	51,7	24	0
1604,9	3735,2	51,3	25	1
1563,1	3469,0	50,0	26	1
1537,5	3290,1	48,8	27	1
1522,1	3068,5	47,7	28	1
1489,4	2633,9	46,4	29	2
1315,5	2466,0	41,4	30	2
1144,8	2355,8	38,2	31	3
1046,0	2286,8	37,6	32	4
971,0	2131,2	30,7	33	4
912,3	1943,1	28,1	34	5
847,2	1792,1	26,1	35	7
772,4	1718,3	21,6	36	8
678,8	1673,1	17,0	37	10
609,9	1579,9	14,0	38	12
557,5	1380,1	11,9	39	14
485,1	1310,3	10,9	40	16
440,7	1175,6	9,9	41	18
402,4	1141,2	8,9	42	21
370,1	1083,7	8,3	43	24
346,8	1019,8	6,9	44	27
319,2	970,8	6,9	45	31
295,9	945,8	6,3	46	34
277,5	924,7	5,9	47	38
267,2	888,0	4,9	48	42
253,1	855,5	4,9	49	46
231,5	806,3	3,9	50	50
213,4	777,8	3,9	51	54
204,7	738,8	3,9	52	58
195,6	721,8	2,9	53	62
181,5	703,5	2,9	54	66
173,5	687,1	2,9	55	69
165,9	662,6	1,9	56	73
159,3	638,9	1,9	57	76
151,5	628,1	1,9	58	79
144,0	613,1	0,9	59	82
137,3	601,6	0,9	60	84
132,7	583,6	0,9	62	86

SD	MDN	Fehler	T Value	PR
123,4	573,8	0,9	62	88
117,9	559,6	0,9	63	90
111,9	537,0	0,9	64	92
109,3	521,9	-0,2	65	93
106,2	503,5	-0,2	66	95
95,2	485,9	-0,2	67	96
82,8	478,7	-0,2	68	96
77,8	473,2	-0,2	69	97
74,1	462,3	-0,2	70	98
69,0	452,9	-0,2	71	98
61,9	441,5	-0,2	72	99
41,0	421,0	-0,2	73	99
23,3	393,4	-0,2	74	99
19,8	373,7	-0,2	75	99
16,5	363,0	-0,2	76	100
13,4	353,1	-0,2	77	100
13,0	351,7	-0,2	78	100
13,0	351,7	-0,2	79	100
13,0	351,7	-0,2	80	100

This table is based on the corrected norm sample, therefore negative values may occur.

### A 3: Divided Attention

#### A 3.1 Divided Attention /auditory

- *No correction of norm values necessary* –

#### Norms

SD	MDN	Error	Omissions	T Value	PR
319,7	1192,2	2,0	3,0	20	0
319,4	1191,8	2,0	3,0	21	0
319,0	1191,4	2,0	3,0	22	0
318,5	1190,9	2,0	3,0	23	0
317,8	1190,1	2,0	3,0	24	0
317,0	1189,2	1,9	3,0	25	1
315,9	1188,0	1,9	3,0	26	1
314,6	1186,5	1,9	3,0	27	1
312,8	1184,6	1,9	3,0	28	1
310,7	1182,1	1,8	3,0	29	2
308,0	1179,1	1,8	3,0	30	2
304,8	1175,6	1,7	3,0	31	3
300,8	1171,2	1,7	3,0	32	4
296,1	1165,9	1,6	3,0	33	4
290,5	1159,7	1,5	3,0	34	5
284,0	1152,4	1,4	3,0	35	7
276,4	1143,9	1,3	3,0	36	8
267,6	1134,2	1,1	3,0	37	10
259,0	1125,5	1,0	3,0	38	12
255,0	1125,3	1,0	2,8	39	14
250,4	1125,1	1,0	2,6	40	16

SD	MDN	Error	Omissions	T Value	PR
245,5	1124,8	1,0	2,3	41	18
240,1	1124,6	1,0	2,1	42	21
235,7	1115,7	0,8	1,8	43	24
231,8	1101,3	0,5	1,5	44	27
227,8	1086,1	0,2	1,2	45	31
224,8	1063,0	0,0	0,9	46	34
224,7	1023,2	0,0	0,6	47	38
223,5	982,2	0,0	0,2	48	42
220,4	951,0	0,0	0,0	49	46
217,3	936,0	0,0	0,0	50	50
213,6	921,0	0,0	0,0	51	54
209,5	910,3	0,0	0,0	52	58
205,6	902,7	0,0	0,0	53	62
200,0	895,2	0,0	0,0	54	66
193,9	892,2	0,0	0,0	55	69
188,1	891,1	0,0	0,0	56	73
179,3	890,1	0,0	0,0	57	76
165,1	886,5	0,0	0,0	58	79
152,2	878,5	0,0	0,0	59	82
140,4	871,2	0,0	0,0	60	84
129,9	864,6	0,0	0,0	62	86
127,9	858,6	0,0	0,0	62	88
127,9	857,5	0,0	0,0	63	90
127,9	857,5	0,0	0,0	64	92
127,9	857,5	0,0	0,0	65	93
127,9	857,5	0,0	0,0	66	95
127,9	857,5	0,0	0,0	67	96
127,9	857,5	0,0	0,0	68	96
127,9	857,5	0,0	0,0	69	97
127,9	857,5	0,0	0,0	70	98
127,9	857,5	0,0	0,0	71	98
127,9	857,5	0,0	0,0	72	99
127,9	857,5	0,0	0,0	73	99
127,9	857,5	0,0	0,0	74	99
127,9	857,5	0,0	0,0	75	99
127,9	857,5	0,0	0,0	76	100
127,9	857,5	0,0	0,0	77	100
127,9	857,5	0,0	0,0	78	100
127,9	857,5	0,0	0,0	79	100
127,9	857,5	0,0	0,0	80	100

### A 3.2 Divided Attention/visual

- *No correction of norm values necessary* –

#### Norms

SD	MDN	Error	Omissions	T Value	PR
156,1	690,5	3,0	1,0	20	0
156,1	690,1	3,0	1,0	21	0
156,1	689,6	3,0	1,0	22	0
156,1	688,9	3,0	1,0	23	0
156,1	688,1	3,0	1,0	24	0
156,1	687,0	3,0	1,0	25	1

SD	MDN	Error	Omissions	T Value	PR
156,1	685,5	2,9	1,0	26	1
156,1	683,7	2,9	1,0	27	1
156,1	681,3	2,9	1,0	28	1
156,1	678,4	2,9	1,0	29	2
156,1	674,8	2,8	1,0	30	2
156,0	670,5	2,7	1,0	31	3
156,0	665,2	2,7	1,0	32	4
156,0	658,9	2,6	1,0	33	4
156,0	651,4	2,5	1,0	34	5
156,0	642,6	2,4	1,0	35	7
155,9	632,4	2,3	1,0	36	8
155,9	620,7	2,2	1,0	37	10
155,8	607,3	2,1	1,0	38	12
155,8	592,2	1,8	1,0	39	14
153,8	585,8	1,4	0,9	40	16
150,9	583,8	1,0	0,7	41	18
147,5	581,7	0,6	0,5	42	21
143,9	579,4	0,2	0,3	43	24
140,1	576,9	0,0	0,0	44	27
130,1	573,3	0,0	0,0	45	31
116,4	569,0	0,0	0,0	46	34
102,1	564,5	0,0	0,0	47	38
87,5	559,9	0,0	0,0	48	42
83,3	522,7	0,0	0,0	49	46
81,8	477,0	0,0	0,0	50	50
80,3	431,3	0,0	0,0	51	54
78,8	394,1	0,0	0,0	52	58
77,3	389,5	0,0	0,0	53	62
75,9	385,0	0,0	0,0	54	66
74,5	380,7	0,0	0,0	55	69
72,4	376,7	0,0	0,0	56	73
69,1	373,1	0,0	0,0	57	76
66,1	369,7	0,0	0,0	58	79
63,3	366,6	0,0	0,0	59	82
60,7	363,8	0,0	0,0	60	84
59,1	362,0	0,0	0,0	62	86
59,1	362,0	0,0	0,0	62	88
59,1	362,0	0,0	0,0	63	90
59,1	362,0	0,0	0,0	64	92
59,1	362,0	0,0	0,0	65	93
59,1	362,0	0,0	0,0	66	95
59,1	362,0	0,0	0,0	67	96
59,1	362,0	0,0	0,0	68	96
59,1	362,0	0,0	0,0	69	97
59,1	362,0	0,0	0,0	70	98
59,1	362,0	0,0	0,0	71	98
59,1	362,0	0,0	0,0	72	99
59,1	362,0	0,0	0,0	73	99
59,1	362,0	0,0	0,0	74	99
59,1	362,0	0,0	0,0	75	99
59,1	362,0	0,0	0,0	76	100
59,1	362,0	0,0	0,0	77	100
59,1	362,0	0,0	0,0	78	100
59,1	362,0	0,0	0,0	79	100
59,1	362,0	0,0	0,0	80	100



### A 3.3 Divided Attention/auditory-visual

#### Trend Correction (Regression Coefficients)

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>
SD Squares	221.3934	0.053	191.452	0	0	0	2.326E-04
MDN Squares	840.7809	0.109	721.359	0	2.547	0	0
Omissions Squares	0	0	0	0	0	0	0
SD Tones	109.0237	0.031	85.895	0	0.492	0	0
MDN Tones	0	0	0	0	0	0	0
Omissions Tones	0	0	0	0	0	0	0

#### Dispersion Correction (Regression Coefficients)

Parameter	M(dis)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>
SD Squares	67.7086	0.018	58.172	0	0	0	7.410E-05
MDN Squares	76.9264	0	0	0	0	0	0
Omissions Squares	0	0	0	0	0	0	0
SD Tones	0	0	0	0	0	0	0
MDN Tones	0	0	0	0	0	0	0
Omissions Tones	0	0	0	0	0	0	0

### Norms

SD Squares	MDN Squares	Omissions Squares	SD Tones	MDN Tones	Omissions Tones	T Value	PR
653,2	1484,7	11,0	270,4	843,4	11,1	20	0
624,7	1426,2	10,6	263,3	825,0	11,0	21	0
591,7	1380,9	10,1	261,5	801,0	11,0	22	0
569,7	1309,2	9,5	255,0	790,5	9,5	23	0
554,8	1244,5	9,0	248,5	785,2	8,0	24	0
544,2	1227,3	9,0	244,3	777,8	6,7	25	1
534,0	1197,3	8,2	234,8	770,7	5,0	26	1
520,0	1180,4	8,0	228,7	766,1	4,0	27	1
507,7	1149,8	7,0	221,7	751,2	4,0	28	1
487,4	1139,9	7,0	212,3	740,9	3,2	29	2
469,4	1116,7	6,0	210,2	735,2	3,0	30	2
454,0	1108,1	6,0	207,6	724,6	3,0	31	3
448,3	1088,5	6,0	199,7	713,1	2,0	32	4

SD Squares	MDN Squares	Omissions Squares	SD Tones	MDN Tones	Omissions Tones	T-Wert	PR
433,7	1073,8	5,0	192,2	699,6	2,0	33	4
417,2	1048,7	5,0	188,9	685,0	2,0	34	5
405,5	1034,9	4,4	184,4	680,4	2,0	35	7
395,7	1019,3	4,0	179,5	671,6	1,0	36	8
386,2	1012,7	4,0	173,5	664,5	1,0	37	10
368,1	998,0	4,0	165,8	655,9	1,0	38	12
347,2	982,0	3,0	160,0	646,1	1,0	39	14
328,7	969,6	3,0	155,4	639,5	1,0	40	16
318,4	947,4	3,0	150,6	631,4	1,0	41	18
302,5	935,3	3,0	144,6	623,9	1,0	42	21
289,0	918,7	2,0	139,1	615,0	1,0	43	24
276,3	904,6	2,0	133,8	604,2	1,0	44	27
266,7	890,5	2,0	128,6	596,0	0,0	45	31
255,5	880,3	2,0	123,6	590,0	0,0	46	34
246,3	870,5	2,0	119,2	581,1	0,0	47	38
236,2	859,3	1,0	115,3	570,0	0,0	48	42
223,4	851,1	1,0	111,1	557,0	0,0	49	46
214,1	840,9	1,0	106,3	547,0	0,0	50	50
203,5	832,7	1,0	102,2	537,6	0,0	51	54
189,4	821,9	1,0	99,5	525,5	0,0	52	58
180,3	809,3	1,0	95,1	513,5	0,0	53	62
173,7	795,7	1,0	91,5	506,7	0,0	54	66
168,1	785,5	1,0	87,6	495,5	0,0	55	69
163,4	775,7	1,0	84,0	485,6	0,0	56	73
159,6	764,8	0,0	80,8	477,8	0,0	57	76
152,1	754,8	0,0	76,5	468,0	0,0	58	79
145,1	744,7	0,0	74,0	463,0	0,0	59	82
137,3	734,3	0,0	72,4	455,2	0,0	60	84
131,3	726,1	0,0	68,0	443,8	0,0	62	86
125,7	719,9	0,0	65,5	437,1	0,0	62	88
120,0	707,6	0,0	63,0	427,0	0,0	63	90
115,0	699,5	0,0	61,4	418,6	0,0	64	92
112,6	687,0	0,0	58,2	410,6	0,0	65	93
107,0	679,5	0,0	56,2	399,0	0,0	66	95
102,8	670,3	0,0	53,0	393,0	0,0	67	96
98,6	657,6	0,0	50,0	386,0	0,0	68	96
95,2	652,9	0,0	47,5	383,0	0,0	69	97
86,3	637,1	0,0	45,8	379,5	0,0	70	98
82,7	629,6	0,0	44,8	359,5	0,0	71	98
80,6	620,3	0,0	43,1	354,7	0,0	72	99
78,3	604,5	0,0	41,7	347,3	0,0	73	99
75,3	592,0	0,0	41,4	345,1	0,0	74	99
75,2	544,6	0,0	39,3	338,4	0,0	75	99
75,1	528,8	0,0	37,8	333,7	0,0	76	100
69,4	518,2	0,0	36,6	310,0	0,0	77	100
65,8	503,9	0,0	35,4	296,8	0,0	78	100
63,8	470,1	0,0	33,4	294,6	0,0	79	100
62,5	446,0	0,0	32,0	293,0	0,0	80	100

This table is based on the corrected normative sample.

**A 4: Go/Nogo****Trend Correction (Regression Coefficients)**

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>
MDN RT	410.8580	0.035	391.869	0	0	0	1.351E-04
SD RT	0	0	0	0	0	0	0
Errors	1.16	0.107	0.524	0	0	0	4.670E-06
Omissions	0.28	0	0	0	0	0	0

**Dispersion Correction (Regression Coefficients)**

Parameter	M(dis)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>
MDN RT	0	0	0	0	0	0	0
SD RT	0	0	0	0	0	0	0
Errors	0.9561	0.044	0.669	0	0	1.144E-04	0
Omissions	0	0	0	0	0	0	0

**Norms**

<b>SD</b>	<b>MDN</b>	<b>Error</b>	<b>Omissions</b>	<b>T Value</b>	<b>PR</b>
272,6	588,7	18,5	15,7	20	0
255,3	588,6	16,8	15,1	21	0
235,1	588,4	14,9	14,4	22	0
209,2	588,1	12,4	13,5	23	0
194,2	583,9	10,7	12,1	24	0
190,4	575,9	9,8	10,2	25	1
184,7	566,5	8,8	7,9	26	1
173,6	564,3	8,5	6,6	27	1
161,1	562,9	8,2	5,0	28	1
153,8	561,0	7,8	3,5	29	2
150,0	558,6	7,3	3,0	30	2
143,7	553,1	7,1	2,0	31	3
135,7	527,4	6,7	2,0	32	4
132,5	525,2	6,3	1,0	33	4
127,4	522,8	5,0	1,0	34	5
124,4	514,4	4,7	1,0	35	7
119,0	507,0	4,0	0,6	36	8
109,3	499,2	3,8	0,0	37	10
105,2	491,0	3,6	0,0	38	12
98,0	483,4	3,3	0,0	39	14
94,7	479,4	3,1	0,0	40	16
92,0	472,6	2,9	0,0	41	18
88,1	466,8	2,6	0,0	42	21
85,8	459,5	2,5	0,0	43	24
82,1	449,8	2,1	0,0	44	27
78,6	439,1	1,7	0,0	45	31
75,3	432,0	1,6	0,0	46	34
73,9	425,8	1,4	0,0	47	38
72,3	415,8	1,3	0,0	48	42
71,2	408,8	1,2	0,0	49	46
69,5	402,4	1,1	0,0	50	50
68,0	397,3	0,9	0,0	51	54
66,9	393,2	0,9	0,0	52	58
64,9	389,9	0,6	0,0	53	62
62,5	381,1	0,3	0,0	54	66
59,6	377,1	0,3	0,0	55	69
58,5	372,6	0,3	0,0	56	73
56,8	369,0	0,3	0,0	57	76
53,9	363,5	0,2	0,0	58	79
53,0	354,7	0,2	0,0	59	82
51,4	345,5	0,0	0,0	60	84
49,5	343,1	0,0	0,0	62	86
48,3	339,6	0,0	0,0	62	88
46,7	331,0	0,0	0,0	63	90
43,7	327,3	-0,2	0,0	64	92
42,8	323,5	-0,2	0,0	65	93
40,4	311,7	-0,2	0,0	66	95
38,8	302,7	-0,2	0,0	67	96
37,6	296,6	-0,3	0,0	68	96
36,9	294,1	-0,3	0,0	69	97
35,6	285,2	-0,3	0,0	70	98
33,6	275,1	-0,3	0,0	71	98
32,1	271,1	-0,3	0,0	72	99
30,6	264,4	-0,4	0,0	73	99
27,9	255,0	-0,4	0,0	74	99
26,6	250,2	-0,4	0,0	75	99
25,7	246,9	-0,5	0,0	76	100

SD	MDN	Error	Omissions	T Value	PR
25,3	245,3	-0,5	0,0	77	100
25,5	245,3	-0,5	0,0	78	100
25,3	245,3	-0,5	0,0	79	100
25,3	245,3	-0,5	0,0	80	100

This table is based on the corrected normative sample.

## A 5: Visual Scanning

### A 5.1 Overall Parameters

#### Trend correction (Regression Coefficients)

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>	Age*Sex
SD critical	1134.1686	0.110	1022.397	0	0	0.111	0	-3.187
MDN critical	2322.0244	0.097	2120.901	0	0	0.189	0	-5.264
SD non critical	837.6118	0.097	920.115	0	0	-0.351	5.833E-03	0
MDN non critical	4303.7596	0.079	4270.040	0	0	0	4.775E-03	-11.900
Omissions	6.62	0.108	4.089	0	0	0	1.863E-05	0
Error	0	0	0	0	0	0	0	0
Row correlation	0	0	0	0	0	0	0	0
Column correlation	0	0	0	0	0	0	0	0

- *No correction for dispersion necessary.* -

### Norms

SD critical	MDN critical	SD non critical	MDN non critical	Omissions	Errors	Row corr.	Column corr.	T Value	PR
3112,5	5672,9	3267,8	11258,6	6,6	9,2	-0,27	-0,39	20	0
3111,0	5613,9	3248,9	11249,0	6,6	8,4	-0,27	-0,39	21	0
3109,3	5545,2	3226,8	11237,8	6,6	7,4	-0,27	-0,39	22	0
3107,1	5456,9	3198,3	11223,4	6,6	6,2	-0,26	-0,39	23	0
3104,2	5339,0	3160,5	11204,3	6,6	4,5	-0,25	-0,38	24	0
3095,4	5198,0	3109,5	11156,8	6,6	2,9	-0,23	-0,38	25	1
3064,5	5034,2	3027,3	11002,9	6,6	2,6	-0,11	-0,31	26	1
3025,9	4829,4	2924,7	10810,6	6,5	2,2	0,0	-0,27	27	1
2954,0	4677,4	2856,1	10567,6	6,5	2,0	0,0	-0,26	28	1

<b>SD critical</b>	<b>MDN critical</b>	<b>SD non critical</b>	<b>MDN non critical</b>	<b>Omissions</b>	<b>Errors</b>	<b>Row corr.</b>	<b>Column corr.</b>	<b>T Value</b>	<b>PR</b>
2861,0	4555,9	2786,7	10208,6	6,5	2,0	0,0	-0,25	29	2
2701,7	4485,1	2369,1	9119,3	6,5	2,0	0,14	-0,23	31	3
2504,9	4428,2	2273,0	8858,6	6,5	2,0	0,17	-0,20	32	4
2337,1	4259,2	2226,5	8784,7	6,4	2,0	0,19	-0,19	33	4
2271,9	4119,3	2020,4	8056,2	6,3	1,6	0,21	-0,18	34	5
2217,3	3999,6	1755,7	7283,4	6,3	1,0	0,25	-0,17	35	7
2082,1	3728,9	1543,4	6908,5	6,1	1,0	0,29	-0,15	36	8
1848,1	3602,5	1490,9	6756,7	5,8	1,0	0,32	-0,14	37	10
1756,5	3525,2	1464,1	6533,1	5,6	1,0	0,35	-0,11	38	12
1664,6	3335,7	1362,3	6321,8	5,5	1,0	0,38	0,0	39	14
1630,5	3196,5	1291,9	6068,9	5,3	1,0	0,42	0,0	40	16
1593,5	3076,0	1263,7	5863,7	5,2	1,0	0,46	0,0	41	18
1544,0	3022,9	1224,2	5759,2	5,2	1,0	0,48	0,0	42	21
1480,8	2940,4	1172,7	5656,6	5,1	0,0	0,52	0,0	43	24
1444,0	2870,0	1069,9	5488,6	4,8	0,0	0,55	0,0	44	27
1399,9	2663,6	1048,3	5305,3	4,6	0,0	0,58	0,0	45	31
1379,8	2624,2	990,7	5194,5	4,4	0,0	0,60	0,0	46	34
1329,3	2584,4	941,9	4943,5	4,2	0,0	0,63	0,0	47	38
1260,6	2499,7	889,9	4812,2	4,0	0,0	0,66	0,0	48	42
1231,8	2441,5	863,4	4607,5	3,7	0,0	0,70	0,0	49	46
1203,0	2381,2	821,8	4464,4	3,1	0,0	0,72	0,0	50	50
1187,7	2341,6	780,9	4279,7	2,8	0,0	0,76	0,0	51	54
1150,3	2282,4	744,0	4188,0	2,4	0,0	0,78	0,0	52	58
1108,1	2226,8	718,4	4127,3	2,2	0,0	0,81	0,0	53	62
1067,2	2187,7	694,4	4017,6	2,0	0,0	0,82	0,0	54	66
1036,6	2129,4	662,4	3877,9	1,8	0,0	0,84	0,11	55	69
996,2	2070,2	651,7	3774,9	1,6	0,0	0,86	0,11	56	73
971,8	2034,3	619,1	3695,5	1,4	0,0	0,87	0,13	57	76
916,4	1956,2	593,9	3609,3	1,1	0,0	0,88	0,15	58	79
882,8	1916,6	566,3	3508,4	0,8	0,0	0,89	0,16	59	82
838,9	1890,4	549,6	3470,0	0,6	0,0	0,89	0,17	60	84
824,4	1829,6	515,5	3401,1	0,6	0,0	0,90	0,19	62	86
811,3	1793,1	502,5	3355,5	0,4	0,0	0,90	0,21	62	88
802,2	1782,5	480,7	3292,6	0,2	0,0	0,91	0,24	63	90
791,6	1769,5	428,7	3233,0	0,0	0,0	0,92	0,26	64	92
758,6	1722,7	398,9	3215,2	-0,3	0,0	0,93	0,29	65	93
744,9	1667,1	392,8	3130,2	-0,4	0,0	0,94	0,31	66	95
722,8	1615,2	382,2	2999,7	-0,5	0,0	0,94	0,32	67	96
664,4	1579,4	381,8	2973,7	-0,7	0,0	0,95	0,35	68	96
648,2	1497,7	376,3	2943,4	-0,9	0,0	0,95	0,37	69	97
617,2	1487,0	374,0	2866,4	-1,0	0,0	0,95	0,41	70	98
593,3	1390,8	360,1	2719,6	-1,1	0,0	0,95	0,42	71	98
569,4	1339,9	338,8	2622,2	-1,5	0,0	0,96	0,48	72	99
522,9	1275,1	310,8	2566,2	-1,8	0,0	0,96	0,49	73	99
435,1	1172,9	269,9	2559,8	-1,8	0,0	0,96	0,50	74	99
364,8	1091,0	237,2	2554,7	-1,8	0,0	0,97	0,51	75	99
351,3	1075,2	230,9	2553,7	-1,8	0,0	0,97	0,64	76	100
351,3	1075,2	230,9	2553,7	-1,8	0,0	0,97	0,76	77	100
351,3	1075,2	230,9	2553,7	-1,8	0,0	0,97	0,81	78	100
351,3	1075,2	230,9	2553,7	-1,8	0,0	0,97	0,81	79	100
351,3	1075,2	230,9	2553,7	-1,8	0,0	0,97	0,82	80	100

**This table is based on the corrected normative sample.**

## A 5.2 Normcorrection for each column

### Trend Correction (Regression Coefficients)

Parameter	M(trend)	R <sup>2</sup>	Constant	Sex	Age	Age <sup>2</sup>	Age <sup>3</sup>	Age*Sex
MDN Co. 1	2404.3149	0.074	1686.754	0	14.864	0	0	0
SD Co.1	1207.5709	0.06	1047.963	0	0	0	1.184E-03	0
Omi. Co.1	1.22	0.063	0.756	0	0	0	3.427E-06	0
MDN Co.2	2370.4984	0.060	2235.209	0	0	0.203	0	-7.226
SD Co.2	0	0	0	0	0	0	0	0
Omi. Co.2	0	0	0	0	0	0	0	0
MDN Co.3	2370.4984	0.060	2235.209	0	0	0.203	0	-7.226
SD Co.3	1116.9293	0.037	878.619	0	4.964	0	0	0
Omi. Co.3	0	0	0	0	0	0	0	0
MDN Co.4	2368.795	0.073	1985.866	0	0	0.154	0	0
SD Co.4	1174.3958	0.060	1018.168	0	0	0	1.156E-03	0
Omi. Co.4	1.17	0.057	0.313	0	0	0	0	1.660E-02
MDN Co.5	2487.9551	0.048	1939.837	0	11.464	0	0	1939.837
SD Co.5	1270.4242	0.062	1083.781	0	0	0	1.392E-03	1083.781
Omi. Co.5	1.81	0.114	1.807	0	0	-1.29E-03	2.381E-05	1.807

**Dispersion Correction (Regression Coefficients)**

<b>Parameter</b>	<b>M(displ)</b>	<b>R<sup>2</sup></b>	<b>Konstante</b>	<b>Geschl.</b>	<b>Alter</b>	<b>Alter<sup>2</sup></b>	<b>Alter<sup>3</sup></b>	<b>Alter*Geschl.</b>
MDN Co. 1	0	0	0	0	0	0	0	0
SD Co.1	0	0	0	0	0	0	0	0
Omi. Co.1	0.9267	0.061	0.591	0	0	1.349E-04	0	0.591
MDN Co.2	0	0	0	0	0	0	0	0
SD Co.2	0	0	0	0	0	0	0	0
Omi. Co.2	0	0	0	0	0	0	0	0
MDN Co.3	558.0763	0.039	733.133	-226.589	0	0	5.03E-04	0
SD Co.3	0	0	0	0	0	0	0	0
Omi. Co.3	0	0	0	0	0	0	0	0
MDN Co.4	0	0	0	0	0	0	0	0
SD Co.4	0	0	0	0	0	0	0	0
Omi. Co.4	0.9598	0.031	0.779	0	0	0	1.343E-06	0
MDN Co.5	0	0	0	0	0	0	0	0
SD Co.5	0	0	0	0	0	0	0	0
Omi. Co.5	1.2963	0.015	1.094	0	0	8.197E-05	0	1.094



## Norms

MDN Co.1	SD Co.1	Omi. Co.1	MDN Co.2	SD Co.2	Omi. Co.2	MDN Co.3	SD Co.3	Omi. Co.3	MDN Co.4	SD Co.4	Omi. Co.4	MDN Co.5	SD Co.5	Omi. Co.5	T Value	PR
8535,1	5256,3	8,7	6221,1	3569,9	7,6	5959,3	3693,9	7,6	6967,3	4382,8	8,8	8755,6	4430,0	14,4	20	0
8285,5	5239,8	8,5	6081,9	3524,5	7,4	5916,7	3635,1	7,4	6876,1	4286,5	8,8	8312,6	4202,0	14,1	21	0
7994,2	5220,5	8,2	5919,5	3471,5	7,1	5866,9	3566,5	7,1	6769,7	4174,2	8,7	7796,3	3935,9	13,8	22	0
7766,4	4918,8	8,1	5743,6	3437,9	7,0	5826,7	3474,8	6,8	6664,2	4004,5	8,5	7426,5	3742,2	13,6	23	0
7634,5	4191,7	8,0	5547,7	3430,4	7,0	5801,0	3348,3	6,4	6560,4	3748,6	8,1	7278,7	3657,7	13,6	24	0
7467,4	3374,7	8,0	5313,2	3417,3	7,0	5762,2	3198,0	6,0	6415,3	3456,4	7,6	7088,4	3560,6	13,5	25	1
7220,1	3328,5	7,9	5117,7	3366,3	7,0	5363,3	3087,1	6,0	6047,6	3382,0	7,0	6770,5	3527,6	13,4	26	1
7093,2	3194,1	7,5	4993,2	3180,2	7,0	5414,7	2985,7	6,0	5688,5	3346,1	6,7	6625,7	3438,8	13,2	27	1
7003,0	3042,7	7,1	4785,2	2966,6	6,4	5245,4	2759,4	6,0	5512,1	3069,5	6,6	6521,0	3363,6	13,0	28	1
6594,7	2846,5	7,0	4640,0	2787,2	6,0	5008,4	2599,8	5,1	5453,9	2873,6	6,6	6440,6	3182,4	12,9	29	2
6358,2	2714,1	6,7	4534,2	2693,8	5,5	4640,4	2451,7	5,0	4880,1	2817,1	6,6	6249,1	3086,8	12,8	30	2
6099,5	2629,2	6,1	4326,7	2605,0	5,0	4473,0	2423,6	5,0	4725,7	2704,9	6,2	5944,0	2965,3	12,6	31	3
6015,0	2433,5	5,8	4278,8	2505,3	5,0	4203,8	2371,0	5,0	4308,5	2632,7	5,6	5677,4	2645,6	12,4	32	4
5856,2	2391,4	5,3	4015,8	2355,8	5,0	4016,1	2290,0	5,0	4196,1	2472,3	5,5	5355,5	2451,1	12,0	33	4
5626,2	2346,8	5,1	3922,2	2201,4	4,0	3797,0	2196,8	4,0	3943,6	2241,0	5,5	4959,3	2378,0	11,5	34	5
5496,9	2242,8	4,8	3835,0	2142,2	4,0	3685,2	2064,4	4,0	3803,1	2163,4	4,8	4590,2	2267,0	11,0	35	7
5410,5	2184,5	4,6	3647,8	2033,1	4,0	3552,8	1869,3	4,0	3751,8	2037,4	4,5	4332,2	2175,8	10,8	36	8
5367,8	2064,5	4,0	3580,5	1869,6	3,0	3477,0	1805,5	3,0	3628,1	1978,7	4,5	4067,1	2090,7	10,5	37	10
5216,0	1968,4	3,8	3467,7	1825,1	3,0	3464,0	1687,5	3,0	3454,0	1896,3	3,8	3958,9	1982,2	10,2	38	12
5095,5	1892,5	3,6	3253,8	1764,0	3,0	3355,6	1639,6	3,0	3278,5	1814,8	3,5	3699,6	1936,2	9,7	39	14
4882,0	1759,3	3,2	3066,3	1656,3	3,0	3243,0	1590,8	3,0	3195,1	1731,9	3,4	3590,0	1840,9	9,4	40	16
4795,3	1701,6	2,8	3006,2	1600,3	2,0	3158,2	1508,6	3,0	3105,3	1662,5	3,4	3447,2	1780,8	8,9	41	18
4697,2	1640,6	2,6	2967,9	1534,0	2,0	3076,1	1453,1	2,0	3009,0	1565,4	3,4	3266,8	1726,7	8,5	42	21
4625,0	1560,5	2,5	2887,4	1463,4	2,0	3004,0	1421,9	2,0	2929,3	1491,6	2,6	3119,4	1672,2	8,1	43	24
4522,5	1481,9	2,4	2795,5	1414,6	2,0	2913,4	1385,8	2,0	2884,3	1468,4	2,4	3027,9	1595,3	7,8	44	27
4408,5	1448,4	2,1	2664,5	1367,1	2,0	2795,9	1359,3	2,0	2794,1	1417,1	2,4	2938,6	1517,4	7,6	45	31
4243,7	1386,8	1,7	2606,2	1306,6	1,0	2683,2	1315,3	2,0	2670,0	1344,1	2,4	2843,0	1471,0	7,2	46	34
4155,5	1351,4	1,6	2487,8	1262,2	1,0	2620,1	1248,0	1,0	2571,1	1303,1	1,7	2782,9	1443,5	6,8	47	38
4058,6	1305,2	1,6	2410,8	1214,1	1,0	2521,6	1222,7	1,0	2473,7	1247,2	1,5	2732,3	1384,1	6,3	48	42
4010,3	1242,7	1,5	2373,4	1172,1	1,0	2450,2	1198,7	1,0	2412,7	1199,3	0,8	2665,2	1337,1	6,0	49	46
3952,9	1183,1	1,3	2317,5	1134,5	1,0	2358,8	1157,9	1,0	2372,4	1166,9	0,6	2578,7	1279,1	5,7	50	50

MDN Co.1	SD Co.1	Omi. Co.1	MDN Co.2	SD Co.2	Omi. Co.2	MDN Co.3	SD Co.3	Omi. Co.3	MDN Co.4	SD Co.4	Omi. Co.4	MDN Co.5	SD Co.5	Omi. Sp.5	T Value	PR
3906,3	1138,2	1,1	2237,1	1100,8	1,0	2309,1	1097,0	1,0	2317,9	1143,1	0,4	2475,0	1208,7	5,5	51	54
3840,6	1094,1	1,0	2185,1	1067,9	1,0	2203,1	1053,1	1,0	2225,1	1112,5	0,4	2399,8	1154,3	5,1	52	58
3740,9	1064,3	0,9	2112,1	1035,3	0,0	2156,0	1012,2	1,0	2177,2	1064,9	0,3	2315,6	1112,2	4,9	53	62
3627,7	1012,1	0,9	2052,0	994,4	0,0	2069,1	990,8	0,0	2135,4	1004,2	0,2	2209,4	1071,4	4,6	54	66
3607,1	984,1	0,7	1982,8	965,0	0,0	2005,7	960,5	0,0	2020,5	940,5	0,1	2136,8	1040,5	4,1	55	69
3545,2	936,8	0,1	1935,0	936,0	0,0	1944,0	904,2	0,0	1971,6	906,4	0,0	2055,5	992,4	3,8	56	73
3453,7	895,5	0,1	1881,4	903,7	0,0	1846,4	880,3	0,0	1940,8	872,7	0,0	2006,2	948,2	3,5	57	76
3405,4	871,8	0,0	1820,5	860,3	0,0	1748,4	842,3	0,0	1890,1	847,0	-0,2	1943,7	907,6	3,2	58	79
3300,8	846,5	0,0	1738,0	812,2	0,0	1702,3	818,1	0,0	1775,8	809,6	-0,4	1873,2	868,8	2,9	59	82
3250,7	827,7	0,0	1646,9	775,0	0,0	1636,0	792,2	0,0	1717,7	778,6	-0,4	1825,1	818,2	2,6	60	84
3196,1	772,8	0,0	1616,7	762,7	0,0	1588,9	748,3	0,0	1664,0	752,1	-0,5	1757,0	771,4	2,4	62	86
3163,6	741,4	0,0	1555,5	747,0	0,0	1538,3	722,2	0,0	1565,6	720,0	-0,6	1698,1	706,7	2,1	62	88
3092,2	705,9	0,0	1509,9	714,9	0,0	1487,8	693,0	0,0	1533,2	689,7	-0,6	1618,9	664,6	1,4	63	90
3071,6	654,9	-0,1	1382,0	694,5	0,0	1454,3	665,9	0,0	1490,7	655,5	-0,6	1555,8	612,4	1,3	64	92
3032,1	642,2	-0,1	1322,7	651,4	0,0	1421,2	620,9	0,0	1377,2	630,3	-0,7	1507,8	564,2	1,0	65	93
2974,5	622,2	-0,2	1275,2	600,6	0,0	1389,0	578,8	0,0	1347,2	595,2	-0,7	1464,3	537,2	0,8	66	95
2896,5	539,6	-0,2	1250,1	583,0	0,0	1349,5	531,1	0,0	1282,0	537,7	-0,7	1403,8	521,5	0,8	67	96
2836,8	570,8	-0,2	1214,4	507,3	0,0	1255,6	515,1	0,0	1256,7	514,4	-0,7	1374,7	500,0	0,7	68	96
2829,6	513,2	-0,2	1135,5	464,7	0,0	1203,1	453,1	0,0	1207,8	447,7	-0,8	1337,7	433,8	0,6	69	97
2798,4	481,9	-0,2	1031,3	430,7	0,0	1077,2	425,2	0,0	1121,2	418,8	-0,8	1286,1	400,7	0,6	70	98
2733,2	397,2	-0,3	919,4	420,0	0,0	1027,3	394,9	0,0	1030,8	381,1	-0,9	1270,1	319,0	0,4	71	98
2681,9	382,6	-0,3	880,2	363,1	0,0	992,6	382,4	0,0	947,7	340,1	-0,9	1245,0	286,7	0,3	72	99
2627,0	357,0	-0,3	845,0	329,1	0,0	961,0	333,8	0,0	915,4	268,4	-0,9	1192,8	235,1	0,3	73	99
2548,8	346,1	-0,3	807,5	315,7	0,0	899,4	260,9	0,0	898,0	182,9	-1,0	1106,2	174,5	0,3	74	99
2509,3	333,3	-0,3	768,0	304,4	0,0	833,7	199,2	0,0	859,5	169,4	-1,0	1033,7	165,1	0,3	75	99
2403,3	226,5	-0,3	740,4	238,8	0,0	785,3	178,9	0,0	855,6	124,7	-1,1	906,3	148,2	0,2	76	100
2295,9	116,1	-0,4	694,6	169,5	0,0	740,3	162,8	0,0	854,8	79,2	-1,3	779,4	131,3	0,2	77	100
2274,6	94,1	-0,4	685,5	154,9	0,0	731,4	159,6	0,0	854,6	70,1	-1,3	754,1	128,0	0,2	78	100
2274,6	94,1	-0,4	685,5	154,9	0,0	731,4	159,6	0,0	854,6	70,1	-1,3	754,1	128,0	0,2	79	100
2274,6	94,1	-0,4	685,5	154,9	0,0	731,4	159,6	0,0	854,6	70,1	-1,3	754,1	128,0	0,2	80	100

This table is based on the corrected normative sample.

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