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# University Language Testing and the C-Test

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# Ten: C-Tests and intelligence[1]

## Ulrich Raatz

In the context of the construct validation of C-Tests this paper will investigate relationships between general language proficiency, as operationalised in C-Tests, and general intelligence, in particular verbal intelligence. How far do the two constructs intersect with each other? This question will be investigated empirically using the techniques of factor analysis.

A number of theoretical and empirical findings suggest that there should be close relationships between the two constructs:

- In an early factorial study with German schoolchildren (Raatz, 1985) in which a C-Test in German and a non-verbal intelligence test were administered a medium correlation emerged between C-Test performance and intelligence, and the factorial structure showed two correlating factors, a language factor and an intelligence factor. Thus language proficiency and intelligence can be combined into a second-order factor.
- In Thurstone's 7 Factor Model of intelligence (1938) at least two factors emerge which are related to language and thus seem to be closely connected to C-Test performance: V (verbal) and W (word fluency).
- Many intelligence tests such as the HAWIK (Bondy, 1956) - the adaptation of the WECHSLER test (Wechsler, 1939) for German children - include vocabulary tests.
- Hofstätter (1966) defines intelligence as the ability to recognise redundancies. Redundancies in language (cf. Oller's expectancy grammar, 1976) are the factor which make it possible to solve C-Tests at all.
- Modern intelligence theories include approaches derived from information theory. If intelligence is defined as the ability for the particularly effective acquisition, processing, storing and output of information, then there are clear links to similar models of language learning and language acquisition (e.g. Skehan, this volume). In both approaches concepts such as speed of information processing, chunking and redundancy play an important role. They are probably also very important in processing C-Tests.
- Oller (1981) claims that language and intelligence may be the same thing because his data of language tests and intelligence tests correlated (between .4 and .6)

[1] The data reported in the following studies were collected by Ruth van der Bruck and Ute Kesper in the context of graduate dissertations. Ute Kesper has also made significant contributions towards interpretation of the data. I would like to thank them both.

These facts and approaches suggest that it would be interesting to investigate systematically the relationships between C-Test performance on the one hand and verbal intelligence, speed of information processing and general language proficiency on the other hand.

## 1. The aims of the study

The expected relationships were to be investigated initially using German L1 populations. Since a sample of data (sample 1) from university students was available from an earlier unpublished study (van den Bruck) this investigation was to be replicated with a second sample (sample 2). In addition it was decided to include a sample of schoolchildren (sample 3) in order to obtain information about the development of relationships between intelligence and language proficiency.

The level of proficiency achieved in the mother tongue, German, was to be operationalised as school grades and C-Test score. In order to measure the various intelligence factors formal intelligence tests were used. Measurement of processing speed was performed using a special formal test, the ZVT (Connection of numbers test), and a crossing-out test. Since the normal speed of writing affects the scores in these tests, this was measured separately. Furthermore the C-Test was to be conducted twice, once in a speeded, once in a non-speeded condition, in order to derive further information about processing speed. This led to the following questions:

- Does mechanical writing speed have an influence on performance on a C-Test in L1?
- Are there relationships between performance on C-Test in L1 and different intelligence factors, in particular speed of information processing, what is usually called verbal intelligence and the reasoning factor?
- Are there differences between schoolchildren and adults in these relationships?
- What is the validity of a C-Test in L1 which is administered under speed conditions?

## 2. Samples

The investigation was performed in three different samples. These are described in Table 1.



**Table 1: The samples**

| Sample | Testform | Group | n | n (Male) | n (Female) | Mean Age |
|---|---|---|---|---|---|---|
| 1 | A | students | 113 | 46 | 67 | 24.3 |
| 2 | B | students | 61 | 22 | 39 | 23.3 |
| 3 | B | children | 112 | 50 | 62 | 11.3 |

## 3. Instruments

For this investigation two comparable German C-Tests, Forms A and B, were developed which consisted of a text with 100 deletions (see C-Test Form B in the Appendix). For the completion of these texts under power conditions 10 minutes were allocated. This time limit permitted all subjects to finish processing the C-Test. In order to determine performance under speed conditions, subjects were instructed to change to a different coloured pencil after 5 minutes. Only the blanks completed using the first pencil were counted for the speed condition.

School grades in German (convergent validity) and in mathematics (divergent validity) were represented in the student group by the grades in the final school leaving examination (Abitur) and in the group of school children by the grade on their last report.

In order to measure the speed and intelligence variables the tests listed in the Appendix were used.

## 4. The investigation

The investigation was performed with Sample 1 (students) in 1994 in the course of two lectures in psychology at the University of Duisburg. 90 minutes were available for the tests. Sample 2 (students) was tested a year later under identical conditions. Sample 3 consisted of four classes of pupils attending the sixth grade at a grammar school in Oberhausen. Here 95 minutes were allocated for the testing.

In all investigations the tests were administered in the same sequence: the writing speed test MWS, C-Test, Speed 1, Speed 2 and LPS with six parts in the original order. During the C-Test subjects were provided with two different coloured pencils and asked to change to the second pencil after 5 minutes. In this way it was possible to determine test performance under speeded conditions.

Unfortunately, with the school children it was only possible to conduct all tests in one of the classes available (n = 28). In the other classes time considerations made it necessary to discard the two last parts of the LPS, tests LPS12 (Closure V) and LPS14 (Perc.speed). Thus the results of this third sample must be interpreted with caution so far as these tests are concerned.

## 5. Results

Table 2 contains the results of the C-Tests in all three samples. The figures refer to the unspeeded condition. The tests were slightly too easy for the school children (P = 64) and very easy for the two student groups (P = 87.1 and 89.4). Surprisingly the variance in samples 1 and 2 is still sufficiently large for substantial correlations with the other variables to emerge. This phenomenon is familiar from other investigations using C-Tests. Even tests which are too easy are still sufficiently reliable and valid.

**Table 2: Results of C-Tests**

| Sample | Testform | Group | n | Mean | SD | min | max |
|---|---|---|---|---|---|---|---|
| 1 | A | students | 113 | 87.1 | 6.5 | 67 | 99 |
| 2 | B | students | 61 | 89.4 | 7.6 | 67 | 100 |
| 3 | B | children | 112 | 13.2 | 13.2 | 34 | 94 |

Although the results for samples 1 and 2 were produced using two different C-Tests in two different years the results obtained in the investigations are very similar. Nevertheless separate analyses were performed in order to check the data against each other.

To investigate the question of the relationships between mechanical writing speed "MWS" and C-Test performance, correlations were calculated between these variables for all three groups. A significant positive correlation would show the existence of such a relationship and would cast doubt on the interpretation of C-Test performance as a measure of general language proficiency. The correlations which emerged were r = .22, r = -.15 and r = -.01 for samples 1, 2 and 3 respectively. A significant positive relationship was therefore not found.

The next step was to determine the concurrent validity of the C-Test. The criteria were firstly the grade in German (the grade in the Abitur or in the last report) and



secondly the sum of the results on the variables "Verbal", "Word flc" and "Closure V" which, according to Horn (1983) are a measure for "verbal proficiency". The validity coefficients are shown in Table 3.

**Table 3: Concurrent validities of C-Tests**

| Sample | Testform | Group | Validities | |
|---|---|---|---|---|
| | | | Grade German | Verbal proficiency |
| 1 | A | students | .29 | .55 |
| 2 | B | students | .22 | .43 |
| 3 | B | children | .55 | .65 |

The correlation of .55 (C-Test B with the school grade in German) for the school children is typical in magnitude for results produced in other investigations. Raatz and Klein-Braley (1992) found a correlation of .61 (Form A) and .54 (Form B) for the CT-D 4, a standardized German C-Test for fourth grade children. There are two possible explanations for the much lower coefficients produced for the two student samples. On the one hand the German grades at Abitur level no longer measure exclusively proficiency in the mother tongue but include other aspects of teaching such as knowledge of literature and performance in literary analysis. On the other hand in most cases more than a year had elapsed for these students since their Abitur examination, and such a time lapse would tend to reduce the correlation coefficient.

The unexpectedly high correlations with "verbal proficiency" as measured by three parts of the LPS in all three groups suggest that C-Tests in the first language measure general verbal abilities which could be summarized as "verbal intelligence". This assumption was investigated in a factor analytic study.

In all three samples a factor analysis using the principal axis method with a varimax rotation was performed over all variables in the study with the exception of mechanical writing speed "MWS". In all three samples three factors emerged which can be identified as a speed factor (SPEED), logical thinking (REASONING) and verbal intelligence (VERBAL IQ). Tables 4 to 6 display the results of these analyses. In order to show the factorial structure more clearly only loadings higher than .39 have been included in the tables.

**Table 4: Factor analysis in sample 1 (38% of variance explained)**

| | SPEED | REASONING | VERBAL IQ |
|---|---|---|---|
| C-Test A | | | .84 |
| Grade German | | | (.24) |
| Grade math | | .46 | |
| Speed 1 | .82 | | |
| Speed 2 | .67 | | |
| Verbal | | | .54 |
| Word flc | .39 | | |
| Closure V | | .40 | |
| Reasoning | | .58 | |
| Space | | | .64 |
| Perc. speed | .55 | | |

**Table 5: Factor analysis in sample 2 (42% of variance explained)**

| | SPEED | VERBAL IQ | REASONING |
|---|---|---|---|
| C-Test B | | .84 | |
| Grade German | | | (.32) |
| Grade math | | | |
| Speed 1 | .65 | | |
| Speed 2 | .61 | | |
| Verbal | | | .56 |
| Word flc | .41 | | |
| Closure V | | .62 | |
| Reasoning | | | .91 |
| Space | | | |
| Perc. speed | .64 | | |



**Table 6: Factor analysis in sample 3 (47% of variance explained).**

| | REASONING | SPEED | VERBAL IQ |
|---|---|---|---|
| C-Test B | .42 | | .55 |
| Grade German | | .44 | .39 |
| Grade math | .54 | | |
| Speed 1 | | .88 | |
| Speed 2 | | .60 | |
| Verbal | | | .68 |
| Word flc | | .52 | |
| Closure V | | .51 | |
| Reasoning | .66 | | |
| Space | | .43 | |
| Perc. speed | .44 | | .61 |

The SPEED factor explains the highest variance in both student samples; it is the second factor in the sample of school children. The tests loading on this factor are both speed tests and the subtests of the LPS which have a speed component. In no case do the C-Tests load on the SPEED factor.

The REASONING factor is the second or third factor in the student samples; the first in the sample of school children. This factor shows loadings for the grade in mathematics and tests which measure logical thinking and spatial perception. For the sample of school children this factor also shows loadings for the grade in German and the C-Test.

The factor VERBAL IQ is the second or third factor in all three analyses. For all three samples there are loadings for the C-Tests, the subtest "verbal" from the LPS which, according to Horn (1983) represents "general knowledge", "verbal knowledge" and "crystallized intelligence" according to Cattell. For the sample of school children this factor also shows loadings for "Word flc" and "Closure V" which together represent the construct "verbal proficiency". This factor can thus be described as "verbal intelligence".

The factor structure is virtually identical for the two student samples. This is remarkable since the two investigations were performed in different years using two different C-Tests. In both cases the C-Tests load only on the 'verbal intelligence' factor and not on the speed factor.

For the sample of school children the factor structure is different. Here both the C-Test and the grade in German load on two intelligence factors, "logical thinking" and "verbal intelligence". This joint double loading explains the high correlations between the grade in German and the C-Test. But here too the speed factor is not relevant.

Obviously in all three samples verbal intelligence plays a role when C-Tests are being processed. The school children also call on logical thought processes. In no case is the speed of mental processing an important variable.

In order to investigate this hypotheses, in particular however to investigate the importance of the grade in German in this network of variables, we next decided to use the available data to predict C-Test performance in all three samples through multiple regression. The predictors selected were the variables Speed 1, the school grade in German and the combined variable "verbal proficiency". Table 7 shows the multiple correlation R, the relevant beta weights and information about the significance levels.

**Table 7: Multiple prediction of C-Test performance**

| Sample | Group | R | Beta Weights | | |
|---|---|---|---|---|---|
| | | | Speed 1 | Grade German | Verb.prof. |
| 1 | students | .47 | -.14 (p>.05) | -.13 (p>.05) | .45 (p<.001) |
| 2 | students | .59 | -.05 (p>.05) | -.21 (p>.05) | .54 (p<.001) |
| 3 | children | .76 | -.29 (p>.05) | -.35 (p<.05) | .70 (p<.001) |

The results show that for the two student samples verbal proficiency alone is the best predictor of C-Test performance. For the schoolchildren verbal proficiency and the grade in German are of almost equal importance.

The final question to be investigated was whether a C-Test administered under speed conditions measures something different from a C-Test under power conditions, for instance whether it had a different concurrent or factorial validity. We therefore replicated all the analyses so far performed using the speeded C-Test instead of the power C-Test. The following results emerged:

- The correlations to mechanical writing speed were r = .05, r = .22 and r = .04. Thus even when the C-Tests themselves are speeded there is a negligible relationship to simple writing speed.



- The coefficients of concurrent validities with the grade in German and the combined verbal proficiency variables are shown in Table 8. The magnitudes of the correlations are similar to those in Table 3, although the correlations with the German grade are slightly lower.
- The three factor analyses produced the same factors with similar loadings. In no case was there a loading for the C-Test on the SPEED factor. There was, however, one important difference: for the schoolchildren processing a C-Test under speed conditions there is only a significant loading on the REASONING factor. The loading for the C-Test on the VERBAL IQ factor disappears. These results indicate that it could be problematical to set a time limit when using C-Tests for children in L1 since this may change the validities.

**Table 8: Validities of speeded C-Tests**

| Sample | Testform | Group | Validities | |
|---|---|---|---|---|
| | | | Grade German | Verbal proficiency |
| 1 | A | students | .13 | .57 |
| 2 | B | students | .22 | .55 |
| 3 | B | children | .33 | .59 |

The results of our investigations can be summarized as follows:

- In no sample was it possible to demonstrate the influence of mechanical writing speed on the C-Test result.
- Adults solve C-Tests in their mother tongue primarily on the basis of their verbal intelligence. Schoolchildren also draw on their reasoning faculties.
- The correlation between C-Test and school grades in the sample of schoolchildren can be explained by joint variance in language proficiency and logical thinking.
- Speed of information processing has no influence on C-Test solving in L1.
- A speeded C-Test in L1 has no higher validity relative to school grades and verbal intelligence.

## 6. Interpretation

In this section the interrelationship between C-Tests and verbal intelligence will be analysed. In addition the question is discussed of why the expected relationship between C-Test performance and the speed of information processing, represented here by the "speed" variable, could not be demonstrated.

In order to interpret these results it is necessary to discuss two recent intelligence models in order to investigate whether these can be related to general language proficiency as it is operationalised in C-Tests. This makes it possible to explain the relationships demonstrated in this study between verbal intelligence and C-Test processing.

### 6.1 Intelligence as neural processing speed

Eysenck (1986) presented a hierarchical integrative model of intelligence. This includes biological intelligence, psychometric intelligence and social intelligence as the most extensive concept. Biological intelligence is the capacity of the central nervous system to process information rapidly and accurately (Neubauer, 1993). Psychometric intelligence is measured by intelligence tests. Eysenck believes that 70% of the variance in psychometric intelligence is determined by biological intelligence, i.e. by the speed at which information is processed. Social intelligence includes biological and psychometric intelligence, and adds further factors such as personality, motivation, experience, coping strategies and health.

These ideas are the basis for the following approach. The human brain has a limited channel capacity for acquiring and processing information. It is assumed that only 16 bits of information per second can be taken into short-term memory. Here they are processed and in some cases transferred into long-term memory. Information which cannot be processed sufficiently rapidly is lost. This means that those people who can process information rapidly can process more information. At the same time processing capacity is freed more rapidly for other cognitive processes (see also Hunt *et al.*, 1975).

Since solving C-Tests involves the taking in and processing of linguistic information it is possible that the correlations between the intelligence tests and the C-Test could be explained by the shared speed variance. We would therefore expect the three factor analyses of this study to reveal a speed factor with loadings for C-Tests, intelligence tests and, in particular, the two speed tests.

However the factor analyses revealed a different structure. While some intelligence tests (word fluency, perceptual speed) and the two speed tests do indeed load on the speed factor, the C-Test does not. We must therefore assume that for C-Tests speed of processing is of relatively small importance. Since the C-Tests were administered without time limits this result is plausible.



### 6.2 The information processing model of intelligence

This model attempts to

> determine the structure of the human mind ... and the mental operations and processes which are involved in every intelligent reaction.(Kail and Pellegrino, 1989: 54).

Memory plays a decisive role in this model too. However here we have a different model of memory. In contrast to the previous model this approach assumes an "activated memory" and a "stored knowledge base". In the knowledge base a qualitative differentiation is made between facts or declarative knowledge and procedural knowledge.

The concept of the activated memory relates to that part of the knowledge base which is needed for information processing at any given time. However the number of knowledge elements which can be activated simultaneously is limited. Processing capacity is restricted to five to seven so-called chunks (Miller, 1956).

The process of connecting pieces of information in a meaningful way or the extension of the knowledge contained in any one chunk to become a larger processing unit is called recoding (Miller, 1956). The limitations of processing capacity can therefore be overcome by rechunking information into larger units.

According to the information processing theory factual knowledge is organised as an associative network which connects entries which are conceptually connected. These entries are known as nodes and are linked by different types of associations.

Access to activated knowledge is not instantaneous but needs a certain time lapse during which the activated memory is searched for the desired information. A precondition for understanding new information is that it can be connected to already active information. This takes place by the process of pattern recognition.

In determining which pattern is relevant in a given situation intuition and expectations play a decisive role. These intuitions and expectations are formed by the knowledge that a person already possesses.

> The conceptual assumptions of a person about what he or she is perceiving guides the process of pattern recognition in a specific direction - hence the term concept-driven processing. (Kail & Pellegrino, 1989: 74, my translation)

According to Kail and Pellegrino, in particular the recognition of letters and words shows the mechanism of concept-driven processing. When sufficient information has been collected about features so that word nodes can be activated, these activated words serve as hypotheses and direct the process of recognition in a particular direction. But it is not only access to knowledge which plays a role in this connection but the type of knowledge available. Adults appear to be more intelligent according to Kail and Pellegrino (1989) because they know more and have more experience. In summary we can conclude that recoding and automatisation enable more information to be processed at any given point in time.

When new information is acquired memory is searched for similar information already present, and this activated information is linked to the new information in order to understand it. Thus a more intelligent person according to this model is someone who knows more, and whose knowledge is more efficiently organised, i.e. linked associatively, because in such people the process of memory search is faster and more efficient.

### 6.3 C-Tests and intelligence

The information processing model of intelligence states that the mechanisms of concept- driven processing can be seen most clearly in the recognition of letters and words. Precisely this is relevant to C-Tests. If the information processing model is applied to C-Test processing, we can make the following assumptions:

- As soon as sufficient information about relevant features has been derived from the word halves and the contexts to activate word nodes (known stored words) these words can be used as hypotheses about the correct restorations and steer the process in a specific direction. In other words, as a result of the word hypotheses other hypotheses are set up about entire sentences, and these in their turn direct intuitions about the entire text. This information is then the basis for reconstructing the next damaged word.
- Thus the reconstruction of deleted word portions in a C-Test involves a series of interactions between hypotheses and reactions in which available knowledge, in this case the language proficiency level attained, plays an important role.

This implies that someone who has a higher level of knowledge in a language, i.e. has reached a higher level of language proficiency, is in a better position to interpret and reconstruct correctly stimulus materials consisting of damaged words. Such a subject has greater access to representations of knowledge (stored knowledge) about the language. For this reason there is a greater probability that available knowledge will be activated which can be used as a hypothesis to focus text reconstruction in a particular direction.

The process of concept driven analysis of stimulus material derived from the information processing model of intelligence can therefore be applied to C-Tests and shows clear parallels to the linguistic assumptions made by Weaver (1965) and Oller (1973) in setting up a theory of cloze test processing.

In an important paper discussing theoretical aspects of cloze procedure, Weaver (1965) explains why he believes that cloze procedure involves both passive language processing and active language production. His remarks apply equally well to processing any reduced redundancy language test:



> There is a plan for generating language, or as I say here, encoding; there is a plan for interpreting language input - decoding. The plans for encoding and decoding may have many similarities, but there are also basic differences. (...) I assume that reading for the practised reader is a maximum-cue, over-practised recognition routine. There is little uncertainty involved in this situation ... The cloze procedure disrupts this decoding process with an instruction for a decision process requiring more or less elaborate search procedures by the organism - at least more elaborate than the ongoing recognition process. There seems to be a shift from some sort of matching process to some sort of search procedure ... At one point in the processing of language materials, then, our subject is reading; at another point he is producing a word to fit a certain context. The procedures relevant to decoding are appropriate on the one hand, and the procedures relevant to encoding on the other. *The cloze procedure enlists the subject in an hierarchical process which goes beyond the ordinary demands of reading* [my italics]. (Weaver, 1965: 116-17).

Oller (1973) similarly assumes that when damaged texts are processed the subject first analyses the information present in the text in order to restore the first blanks. These restorations in their turn are the basis for the next steps in analysis. His expectancy grammar also posits hypothesis-building as a basis for successive restorations. Here too the hypotheses focus text restoration in a particular direction. If the expectancies are not confirmed the theory states that they are either modified or rejected in favour of new hypotheses. These expectancies are viewed by Oller (1973) as manifestations of the basic underlying linguistic competence.

Thus both the linguistic and the psychological theorists assume a knowledge-driven analysis of the available information (damaged text) which is the basis for hypothesis development which then steers the process of text reconstruction. This process is the more successful the more knowledge the subject has available (→intelligence theory) or the greater his or her linguistic competence is, i.e. the more developed the internalised grammar (→linguistic theory) is.

In this context intelligence - a relatively extensive and well-organised body of factual knowledge in the mother tongue - or verbal intelligence - is closely connected to Ollers' (1976) postulated general language proficiency factor and thus with C-Test performance if C-Tests are viewed as instruments measuring this factor of general language proficiency. This explains the findings presented in the factor analyses above: C-Tests have high loadings on the verbal intelligence factor.

But there is another close similarity between the two approaches which implies that people with a higher verbal intelligence will be able to process damaged texts - and also C-Tests - more effectively and more speedily. Both Oller (1973) and

Weaver (1965) on the one hand and the researchers working on the information processing model of intelligence assume that people who have more linguistic knowledge will find it easier to combine information into larger chunks, which means that they can process more information in a given time unit as a result of recoding and automatisation. Someone who knows more can process more information simultaneously and thus increase the speed of information processing.

Both theories thus enable us to draw the conclusion that the process of chunking is a further advantage in the reconstruction processes involved in C-Test performance in terms of efficiency and speed. If someone has more knowledge in a given language, i.e. a higher level of language proficiency, he or she can process more information in a certain time and make better use of the natural linguistic redundancy of a text in order to restore the missing portions of a C-Test correctly.

### 6.4 Age differences

In our factor analyses the C-Test loaded in the two student groups only on the factor VERBAL IQ, in the group of schoolchildren also on the factor REASONING. This result may be explained as follows. There is evidence that metalinguistic processes are less effective in children than in adults, and that language proficiency is dependent on age. So children need additional proficiencies and strategies in C-Test taking. That could be the reasoning dimension of intelligence. Fischer and Mandl (1982) say that metalinguistic processes are only one aspect of dealing with a text. They are part of metacognitive processes defined as generalized strategies which can be drawn on for problem solving in any task. And Hakes states:

> that children, more often than adults, should find themselves in situations in which their limited automatic processes are not successful. And these, of course, are just the situations in which to achieve success, those automatic processes must be supplemented by more controlled processes. (Hakes, 1982: 210)

So we are able to understand the different factor structure of C-Test in schoolchildren.

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## APPENDIX

### Tests used

C-Test, form B

Die Katze gilt als pflegeleicht. Denn s_____ bellt nic_____, kostet ke_____ Steuer, d_____ lästige „Gassi_____" entfällt, u_____ wenn s_____ mal wie_____ in d_____ Gardine schau_____, setzt Frau_____ „Muschi" ein_____ vor d_____ Tür. Beso_____ Berufstätige, d_____ eigentlich ke_____ Zeit f_____ Tiere ha_____, greifen des_____ gern z_____ Katze. I_____ den grü_____ Vororten d_____ Mittelschicht re_____ sich e_____ Miez-Haus a_____ andere. D_____ Folgen si_____ verheerend. De_____ draußen v_____ der T_____ wird d_____ reizende Schmus_____ zur reiß_____ Bestie. „D_____ angeborene Jagd_____, den si_____ auch d_____ Hauskatzen bew_____ haben, ka_____ selbst du_____ überreichliche Fütt_____ nicht unterd_____ werden", wa_____ Professor Dr. Wolfgang Gerß. D_____ Katze lä_____ das Mau_____ nicht. Do_____ es si_____ nicht n_____ lästige Naget_____, die i_____ zum Op_____ fallen. „D_____ Katzen ste_____ fast d_____ ganzen übr_____ Tierwelt a_____ Feinde gege_____; deshalb i_____ der Sch_____, den s_____ anrichten, außeror_____ bedeutend", wu_____ schon Alfred Brehm. He_____ ist al_____ noch schl_____. „Unsere Stadt_____ werden vielf_____ durch d_____ fast völ_____ Fehlen d_____ Nager i_____ ihrem Rev_____ geradezu gezw_____, sich a_____ Vögel z_____ halten, u_____ ihre aufges_____ Jagdstimmung abzure_____", stellt Deutsc_____ Katzen-Papst, Prof_____ Paul Leyhausen, i_____ seiner „Unters_____ an Kat_____" fest. M_____ Vorliebe wer_____ die Nes_____ der Stra_____- und Bodenb_____ leergefressen. „D_____ hören d_____ Nestlinge na_____ Futter ru_____ und kra_____ sie si_____", berichtet För_____ Heinz Nöllenheidt a_____ dem Arnsberger Wa_____. „Manche Kat_____ sind so erfahren, die lassen die Jungen erst mal eine Woche alt werden, damit sich die Sache lohnt".



**Table 8: The variables and their operationalization**

| Variable | Source | Time | Construct | Task |
|---|---|---|---|---|
| **MWS** | own development | 1 minute | mechanical speed of writing | to write two given letters as many times as possible |
| **Speed 1** | Test d2 (Bricken-kamp, 1983) | 20 seconds each row | speed of information processing (concentration) | to mark each d with two dashes in 14 rows, each 47 letters with dashes |
| **Speed 2** | ZVT-Test (Oswald & Roth, 1987) | 30 seconds each page | speed of information processing as basic factor of intelligence | to connect on two pages the digits from 1 to 90 in ascending order |
| **Verbal** | L-P-S (Horn,1983) Part 1, 2 | 5 minutes | verbal comprehension | to mark the wrong letter in each word in a list of 80 words |
| **Word flc** | L-P-S (Horn,1983) Part 6 | 3 minutes | word fluency | to write words as many as possible beginning with a given letter |
| **Closure V** | L-P-S (Horn,1983) Part 12 | 2 minutes | speed of closure (verbal material) | to mark the wrong letter in each word in a list of 40 partially destroyed words |
| **Reasoning** | L-P-S (Horn,1983) Part 4 | 8 minutes | reasoning factor of intelligence, fluid intelligence | to mark the number or letter which does not fit the order in 40 rows of 9 items |
| **Space** | L-P-S (Horn,1983) Part 9 | 3 minutes | space factor of intelligence | to count the surfaces of 40 three-dimensional drawed figures |
| **Perc.speed** | L-P-S (Horn,1983) Part 14 | 2 minutes | perceptual speed | to compare two lists of digits and to mark the deviant digits |