A picture naming test for Dutch adults:

DNT-II

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SAMENVATTING

Achtergrond: Een benoemtest kan helpen bij het identificeren van woordvindingsstoornissen. Bij Nederlandse volwassenen, zoals patiënten met verworven hersenletsel of neurodegeneratieve ziekten, is het nog onvoldoende mogelijk om woordvindingsstoornissen goed te diagnosticeren vanwege het ontbreken van een valide en betrouwbaar onderzoeksinstrument. Daarom is een nieuwe benoemtest ontwikkeld: DNT-II. Bij de selectie van testitems is rekening is gehouden met woordverwervingsleeftijd en woordfrequentie vanwege hun invloed op het woordvindingsproces.

Doel: Het aantonen van effecten van woordfrequentie en woordverwervingsleeftijd op reactietijden van correct benoemde foto's door jongere en oudere gezonde volwassen Nederlandse moedertaalsprekers.

Methoden en procedures: Deze studie heeft een experimenteel psycholinguïstisch kwantitatief design. Dertig gezonde volwassen Nederlandse moedertaalsprekers verdeeld in twee leeftijdsgroepen hebben 99 foto's benoemd van woorden waarin woordverwervingsleeftijd (vroeg/laat) en woordfrequentie (hoog-/midden-/laagfrequent) op alle mogelijke manieren zijn gecombineerd: vroeg/hoogfrequent, vroeg/middenfrequent, vroeg/laagfrequent, laat/hoogfrequent, laat/middenfrequent en laat/laagfrequent. Reactietijden van de correct gegeven antwoorden zijn statistisch geanalyseerd met een Kruskal Wallis Test. Indien deze test significant was zijn telkens twee woord-subgroepen met elkaar vergeleken middels de Mann-Whitney U Test. Het leeftijdseffect is geanalyseerd met de Mann-Whitney U test.

Resultaten: Reactietijden werden significant beïnvloed door woordverwervingsleeftijd en in mindere mate door woordfrequenties. Vroeg verworven en hoogfrequente woorden werden sneller benoemd dan laat verworven en laagfrequente woorden. De verklaarde variantie in reactietijden was het hoogst wanneer de factoren woordverwervingsleeftijd en woordfrequentie werden gecombineerd.

De jonge deelnemers waren significant sneller in het benoemen van foto's van vroeg en laat verworven hoogfrequente woorden dan de oudere deelnemers.

Conclusie: Door inclusie van de variabelen woordverwervingsleeftijd en woordfrequentie is de DNT-II niet alleen in potentie een gevoelig diagnostisch hulpmiddel om woordvindingsstoornissen vast te stellen, maar biedt deze test ook de mogelijkheid om te bepalen welke stap/stappen van het woordvindingsproces beschadigd is/zijn.

Kernwoorden: Benoemtest, volwassenen, woordverwervingsleeftijd, woordfrequentie.

ABSTRACT

Background: A picture naming test can be useful in identifying anomia (naming difficulties). For Dutch adults suspected to have anomia, such as patients with acquired brain injury or neurodegenerative diseases, there is no reliable and valid tool to diagnose anomia properly. Therefore, a new picture naming test is developed: DNT-II. In selecting test items, Age of Acquisition of words (AoA) and word frequency taken into account because of their influence in the process of naming.

Aim: To demonstrate effects of AoA and word frequency on latency of correctly named pictures in younger and older healthy Dutch adults.

Methods and procedures: This study has an experimental psycholinguistic quantitative design. Thirty healthy Dutch adult native speakers in two age groups named 99 coloured pictures of words with AoA (early/late) and word frequencies (high-/mid-/low word frequency) in all possible combinations: early/high frequency, early/mid frequency, early/low frequency, late/high frequency, late/mid frequency and late/low frequency. Latencies of correctly given answers were statistically analysed with a Kruskal Wallis Test. In case of significance, pairwise comparisons between word subgroups were conducted using the Mann-Whitney U Test. Age-effect on latency was analysed with the Mann-Whitney U Test.

Results: Latencies were significantly influenced by AoA and to a lesser extent by word frequencies. Early AoA and high frequency words were named faster than late AoA and low frequency words. Explained variance in latencies had highest values when AoA and word frequency were combined.

Young participants named pictures of early and late acquired high frequency words significantly faster than the older participants.

Conclusion: With the inclusion of both variables AoA and word frequency the DNT-II not only has the potential to be a sensitive diagnostic tool to diagnose naming disorders in Dutch adults but also the ability to determine which step/steps of the word retrieval process is/are impaired.

Keywords: Picture naming test, Adults, Age of Acquisition, Word frequency.

INTRODUCTION

Naming difficulties, also known as anomia are one of the most common characteristics in people with aphasia (1,2) sometimes even the only striking symptom (3). In neurodegenerative diseases like dementia it can be a first sign of language impairment (4).
Naming is part of a complex cognitive process, which has been incorporated in several language and speech models (5-7). These models all agree that picture naming involves four main processing steps (8) namely conceptual preparation, lexical selection, word form encoding and finally articulation (9-11). Step one is at a preverbal level and step four is concerned with speech output. This present study focusses on step two and three of this process.
Impairment in step two and three can lead to word finding difficulties possibly accompanied by increased latency (12). Impairment in the second step is characterized by problems in retrieving semantic information of the verbal concept of words leading to incorrect selection of words, for instance saying “cat” to a picture of a dog (10). Impairment in the third step may result in problems in word form retrieval leading to phonological errors.
Ease and speed of retrieval of semantic and phonological information are strongly influenced by word frequency and age of acquisition of words (AoA) (12). AoA is the age at which a word is typically acquired in language development (13). Words acquired early in life are easier to name and more resistant to brain damage than words acquired later (12); AoA has a particularly strong effect on the semantic selection of words (14). As to word frequency, generally it is easier to retrieve and name high frequency than low frequency words (12,15); word frequency is strongly associated with word form retrieval (16).
Naming is also influenced by age, gender and level of education (13,17). Other possible factors of influence are name agreement, image agreement and word length (18). Name agreement is defined as the degree to which people use the same name for a given object. Image agreement is how closely a picture of a word resembles peoples mental image of that picture (18).

For proper diagnosis and to monitor changes in naming ability across time a picture naming test is considered a well-established diagnostic instrument for people suspected to have naming difficulties, such as patients with acquired brain injury or neurodegenerative diseases (19). A frequently used picture naming test in the Netherlands is the Boston Naming Test (BNT). This test is developed in the United States in 1983. However, using the BNT to diagnose naming difficulties has several disadvantages, namely inadequate norms and standardization, and limited availability of psychometric properties. Furthermore, the BNT does not live up to contemporary views of the cognitive process underlying naming.

Therefore its diagnostic value is questionable (19). Moreover, the Dutch version of the BNT is a literal translation of the American English items.

Limitations of the BNT and the lack of other suitable diagnostic tools have prompted the development of a Dutch picture naming test (DNT) (20). A pilot study with people with aphasia revealed that this DNT was not sensitive enough to diagnose naming difficulties properly (21). However, in this trial version of the DNT, AoA was not included as predictor variable and word frequencies were selected from the CELEX database (22).

To develop a suitable Dutch picture naming test two main factors are important. Firstly, recent research shows that the SUBTLEX database provides a more realistic word frequency count than the CELEX database does. The SUBTLEX database is based on words found on the internet, in primary and secondary school books and movie subtitles whereas the CELEX database is only based on formal written texts (22).
Secondly, as AoA is an important factor in naming ability, it should be taken into account in selecting suitable test items (12). This enables better discrimination between normal and impaired naming ability and better distinguishing between word finding difficulties due to semantic and/or phonological impairments.

AIM

The aim of this study is to demonstrate effects of age of acquisition of words (AoA) and word frequency on latency of correctly named pictures in younger and older healthy Dutch adults in a newly developed picture naming test. This enables further composition of a valid and reliable tool to diagnose naming difficulties properly and monitor changes in naming over time in Dutch people who suffer from aphasia or neurodegenerative diseases with naming difficulties.

METHOD

Design

This quantitative study has an experimental psycholinguistic design and consists of two parts. Firstly, a new Dutch picture Naming Test (DNT-II) was constructed. Secondly, the effect of the predetermined psycholinguistic factors AoA and word frequency on latencies of correctly named pictures was investigated in this DNT-II with a group of younger and older healthy Dutch adults. Both procedures took place from February to April 2016.

Participants

The study population is a sample of healthy Dutch native speakers. In order to be eligible for this study a volunteer had to meet the following inclusion criteria: healthy Dutch native speaker between 18-30 or 50-70 years old. Participants were excluded in case of history of neurological damage, language disorder during childhood, dyslexia, speech disorder (i.e. stuttering) or a hearing or vision problem not-corrected-to-normal. A total of thirty healthy Dutch adults were included in this study. Two age groups of fifteen persons each were formed to investigate the influence of age on latency (17). Volunteers in group I were aged between 18-30 years and in group II volunteers were aged between 50-70 years (table 1). To control for a possible influence of level of education and gender these factors were represented as equally as possible into the two age groups (13).

This study is conducted according to the principles of Helsinki (23). As confirmed by the Medical Ethical Screening Committee of the Faculty of Health of the University of Applied Sciences Utrecht, no approval is needed by the Medical Research Committee, because this research is complying with the Dutch law on Medical Research in Humans. Participants gave written informed consent before participation.

Construction of DNT-II

A new Dutch picture naming test (DNT-II) was developed by using the SUBTLEX database to obtain values of AoA and word frequencies. Six word categories were formed by combining AoA (early and late) with word frequency (high, mid and low frequency words):

1: early high frequency words (EHF), 2: early mid frequency words (EMF), 3: early low frequency words (ELF), 4: late high frequency words (LHF), 5: late mid frequency words (LMF), and 6: late low frequency words (LLF).

High frequency words are defined to have a frequency count of at least 50 occurrences per million and low frequency words fewer than five per million (24). Based on those values, mid

frequency words are supposed to have a frequency count between five to 50 occurrences per million.
In selecting proper items for the DNT-II, words acquired at five years of age or earlier are classified as early acquired and words acquired later than five years of age are classified as acquired late. Also a word had to meet the following criteria: it had to be a noun, it could be depicted in a picture, the named picture could be expressed in one word and AoA and word frequency were derived from the SUBTLEX database.

The SUBTLEX database was searched for words with an AoA between zero and nine years. The values of AoA of the derived items from the SUBTLEX database are based on estimations of Flemish Dutch adult native speakers. It is not clear whether these are comparable for Dutch adult native speakers. Therefore in a pilot study correlations between Dutch AoA norms of adult native speakers from the Netherlands and the SUBTLEX data were determined. Dutch adult native speakers were approached to fill in an online wordlist consisting of 185 suitable test items for the DNT-II and a Pearson's product-moment correlation coefficient was calculated. In case of skewness data were log transformed.
Subsequently, 99 of these 185 words and corresponding coloured photographs were selected for the DNT-II, taking into account the earlier mentioned six word categories (Table 2). It should be noted that for naming it does not matter whether an item is depicted in a black-and-white line drawing or a coloured photograph (25). However unpublished research amongst 20 healthy adults and 20 patients with aphasia showed a preference for coloured photographs (26). Finally the DNT-II was digitized using the Zep Experiment Control Application 1.12 (27). This was done on a FUJITSU Lifebook A532 laptop (28), screen size 15,6-inch and pixels 920x700.

Procedure

Each participant was tested once by the student researcher with the DNT-II. All pictures were displayed in random order on the laptop. Each picture was preceded by a red cross to fix the eyes of the participant on the same spot of the screen where the image was presented. The laptop was placed in front of the participant and the student researcher sat next to the participant. An external keyboard was used by the student researcher to proceed to the next item. Participants were instructed to name the demonstrated picture in one word. During test administration audio recordings were made using a ZOOM H6 Handy Recorder with a ZOOM XY stereo microphone (29). This recorder was placed in front of the participant. Although participants were tested at different places the measurements took place under the same circumstances namely a quiet low-stimulus environment.

Data collection

All audio recordings were transcribed and analysed with respect to correct versus incorrect answering. Answers were correct when the target word or a singular, plural or diminutive form of the target word was produced. All other responses were considered to be incorrect and were not analysed further. Subsequently, audio recordings were used to measure speech-onset latencies. This was measured by hand in milliseconds using the software application Audacity 2.1.0 (30). Latency was measured from the moment of presentation of the image to the onset of the first phoneme of the participant's correct response. Simultaneously with picture onset a non-audible beep was programmed. In Audacity this beep was audible and visualised by a vertical bar, with the left side of the bar as starting point of picture onset. All other sounds, including participants utterance were represented as a wave-signal.

Data analysis

Mean reaction times were analysed using nonparametric tests because the gathered data were highly skewed and did not meet the assumptions of bivariate normal distribution. Kruskal Wallis Tests were conducted to investigate overall significant difference between mean ranks of mean latencies for all the six word categories as defined in Table 2; in succession for the total group of participants, the young group and the older group. In the same way the influence of AoA and word frequency on mean ranks of mean latencies were analysed separately.

The overall influence of age on latency was statistical analysed with the Mann-Whitney U Test. Subsequently a significance of age difference on latencies within the same word groups was statistically analysed with the Mann-Whitney U Test. Significance level is adjusted for the number of groups that were compared (Bonferroni correction). All data were analysed using SPSS version 20 (31).

RESULTS

Construction of DNT-II

Online approaching of people to fill in the online wordlist to determine Dutch AoA norms of 185 words, yielded 96 online forms. Three forms were excluded because they were filled in by participants younger than 18 years. The remaining 93 forms were filled in by 28 men and 65 women, varying in age from 18 to 81 years.

The calculated Pearson's product-moment correlation coefficient showed a significant strong positive correlation between values of AoA-ratings of the online wordlist and those of the SUBTLEX database ($r=0.847$; $p<.000$; significance at a 0.01 level (2-tailed)). A scatterplot summarizes these results (Figure 1). It should be noted that prior to the calculation of the Pearson's product-moment correlation, data were log transformed because data were highly skewed.

Participants of DNT-II

Participants were recruited by means of advertising in the circle of family, friends, acquaintances and colleagues of the student researcher and consisted of 30 persons: 12 males and 18 females (Table 1).

Testing with DNT-II

All participants completed the picture naming test (DNT-II). Duration of the test was 10 to 15 minutes. Seven items of the DNT-II were excluded from further analysis because there was a great diversity in naming. A total of 92 items remained (Table 3). Each item was named by 30 participants, so 2760 answers were investigated. From this count, 226 responses were incorrect, including three times the phrase "I do not know", which leaves 2534 correct answers (91,8%) for further analysis. Mean latencies per correct item were computed by dividing total latency per item by the number of correct item productions.

Influence of AoA combined with word frequency on mean latency

A Kruskal Wallis Test demonstrated an overall significant difference between mean ranks of mean latencies of the six word categories (Table 2) in which AoA and word frequency were combined. There is a significant difference between these word categories for the whole group of participants ($H(5)=23.611$; $p<.000$) as well as for age group I, the young participants ($H(5)=27.387$; $p<.000$) and age group II, the older participants ($H(5)=20.784$; $p<.000$). Post hoc pairwise comparisons with the Mann-Whitney U Test revealed significant differences in mean ranks of mean latencies between subcategories of words. A total of 15 different combinations of word subgroups were compared and significance level was adjusted

accordingly. In the total group of participants, differences in mean ranks of mean latencies between two pairs of word categories were significant. In the group of young participants four pairs of word categories were significant and in the group of older participants there was significance between three pairs of word categories. Table 4 gives an overview of these results.

Influence of AoA on mean latency

A Kruskal Wallis Test showed an overall significant difference between mean ranks of mean latencies of early and late acquired words. There is an overall significant difference between early and late acquired words in the total group of participants ($H(1)=17.668$; $p<.000$) as well as for the young participants ($H(1)=15.64$; $p<.000$) and the older participants ($H(1)=20.78$; $p<.000$). Post hoc pairwise comparison yielded significant differences between mean ranks of mean latencies of early and late AoA in the group of all participants, in the young group and in the older group. Table 5 summarises these results.

Influence of word frequency on latency

A Kruskal Wallis test was performed to examine the difference between mean ranks of mean latencies between high, mid and low word frequency. An overall significant difference in latencies was found in the total group of participants ($H(2)=7.97$; $p=.019$) as well as for the young participants ($H(2)=13.43$; $p=.001$); not for the older participants ($H(2)=2.24$; $p=.326$). Post hoc pairwise comparison yielded significant differences between mean ranks of mean latencies between the word subgroups high and low frequency (HF-LF) and mid and low frequency (MF-LF). These results are presented in Table 6. Another finding is that values of mean ranks of mean latencies of high and mid frequency words are close to each other.

Explained variance of AoA and word frequency

The explained variance was calculated for the variables AoA, word frequency and the combination of these variables. For all groups the explained variance had the highest score when AoA and word frequency were combined (Table 8).

Influence of Age on latency

A Mann-Whitney U Test was performed to examine differences in latencies between the two age groups. An overall significant difference was found in latencies between younger and older participants (U=3040.5; Z=-3,296 (Asymptotic significant .001 (2-tailed)). Thereafter differences were examined between mean ranks of mean latencies within the same word subgroup for the different age groups. For two of those word groups, namely early and late

acquired high frequency words (EHF and LHF words) the differences in latencies for the young and older participants were significant (Table 8).

Correct picture naming

Eighty-eight pictures were named correctly with a percentage of more than 75%. Three words were named correctly with a percentage between 70-75% and for two words this was 56,7%. For all 92 pictures the percentage of correct answers was computed (Table 3).

DISCUSSION

Main findings

The aim of this study was to demonstrate effects of word frequency and AoA on latency of correctly named pictures in younger and older healthy Dutch adults in a new Dutch picture Naming Test (DNT-II).

An important finding in designing the DNT-II is that norms of AoA of the SUBTLEX database, which are based on Flemish Dutch adult native speakers, are highly correlated to those of Dutch adult native speakers (Fig 1). This implicates that AoA norms of the SUBTLEX database are equally reliable as those based on the online word list, which confirms reliability of our data. For cultural consistency, AoA norms based on the online wordlist are used in the DNT-II.

Another important finding is that testing with the DNT-II shows that AoA, more than word frequency influences latencies in picture naming. This supports findings in other studies that with respect to picture naming AoA is an important variable to take into account (18,32-34). Testing with the DNT-II also demonstrated that explained variance on latency of the selected words has highest values when variables AoA and word frequency are combined (Table 8).

Naming words in the DNT-II are a combination of both factors AoA and word frequency (EHF, EMF, ELF, LHF, LMF, and LLF). This makes the DNT-II not only sensitive to detect naming difficulties but also the potential to determine which step or steps of the word retrieval process are possibly affected because AoA is supposed to be mostly related to the second step of word retrieving (14) and word frequency to the third step (16).

The previously designed Dutch picture naming test and the Boston Naming Test (BNT) only took word frequency into account as influential factor in picture naming. Because word frequency is strongly related to the third step of the naming process, with both these tests, impairment in the second step of the naming process remains unclear. In addition, the Dutch version of Boston Naming Test is a literal translation from American English with corresponding word frequencies. This makes the Boston Naming Test (BNT) even more inappropriate for proper diagnosis of naming difficulties in Dutch adults because word frequency values are language specific (12).

To the best of our knowledge the DNT-II is the first picture naming test for Dutch adults in which AoA is included and takes into account all steps of word retrieval.

Strengths and Limitations

This study knows several strengths. Firstly, the chosen cut off point of AoA for the Dutch language in the Netherlands. The chosen value of five years is based on the description of language acquisition in Dutch children. Until the age of five, word vocabulary is about 2500 words, mostly concrete words. After the age of five years, vocabulary is more extensive also with abstract words (35).

Secondly, the chosen study population with two age groups and the controlled variables level of education and gender between both groups made it possible to examine the influence of age on picture naming (Table 8). The significant differences in latency between the word groups EHF and LHF words are most likely based on difference in age because all other variables remained the same.

Thirdly, in testing with the DNT-II, same procedures were followed for all participants.

To appreciate other findings of this study, some limitations need to be considered. Firstly, the six word categories (Table 2) differed in number of words because in general there are very few early AoA low frequency words (ELF) and late AoA high frequency words (LHF) (32). In this current experiment it was also difficult to find enough words for the category mid frequency words combined with late AoA (LMF). A possible explanation is the limited words used in the online word list to determine AoA. As to word frequency, the values of mean ranks of mean latencies of high and mid frequency words are not very distinctive from each other. A possible explanation can be the chosen values of mid frequency words. These are based on cut off points of high and low word frequencies; not on values of mid word frequency itself. The question rises whether mid frequency words are redundant. Perhaps with a greater sample size and performed in people who are suspected of naming difficulties, differences in mean ranks of mean latencies of high and mid frequency words may be significant after all.

Secondly, the used words and pictures are not controlled for respectively name and image agreement. In testing with DNT-II 67 items were correctly named with a percentage of 90 or more. For these items it seems fair to say that participants have consensus on name and image agreement. For the other 25 items this is not clear. In further development of the DNT-II it is recommended to investigate name and image agreement for those items.

Thirdly, word length can be a factor of influence in latency, dependent of measurement: number of letters, phonemes or syllables. In particular number of syllables may influence latencies but this is language-dependent (18). It is not clear whether this was the case in this present study. In standardization, word length is a factor to take into account.

Fourthly, the study population originates from a limited area of the Netherlands and is rather small. A larger population could have given more statistically significant results.

RECOMMENDATIONS

In further development of the DNT-II it is recommended to perform a pilot study with this DNT-II among Dutch adult patients with acquired brain injury and neurodegenerative diseases, with and without the suspicion of having naming difficulties so that ultimately a valid and reliable diagnostic instrument is developed to diagnose naming disorders properly.

CONCLUSION

There are many factors of influence in picture naming. In piloting the DNT-II, AoA appeared to be an important factor. With the inclusion of both variables AoA and word frequency the DNT-II not only has the potential to be a sensitive diagnostic tool to diagnose naming disorders in Dutch adults but also the ability to determine which step/steps of the word retrieval process is/are impaired.

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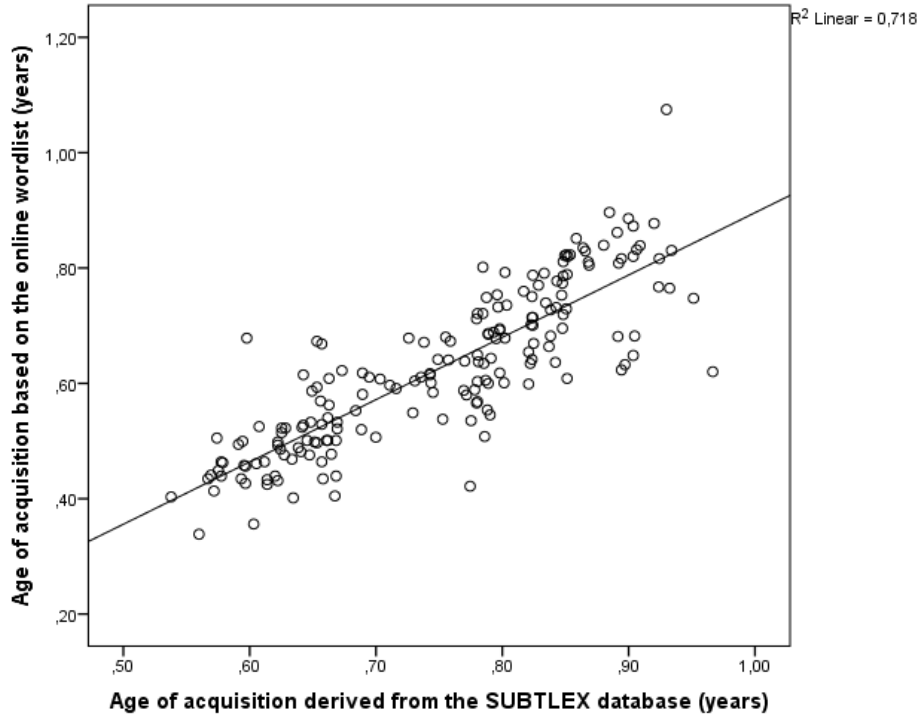
TABLES AND FIGURES

Figure 1. Correlation between age of acquisition (AoA) of SUBTLEX and online wordlist



Note.

Data are log transformed

Table 1. Demographic characteristics of participants

		Group I	Group II
Participants	N	15	15
Age (years)	Mean (s.d.)	25 (3.5)	53 (3.7)
	Range	18 – 29	50 – 64
Gender	Male	6	6
	Female	9	9
Educational level [a]	**Male**		
	Low	-	-
	Medium	2	2
	High	4	4
	Female		
	Low	-	1
	Medium	5	4
	High	4	4

Note.
N=number of participants; s.d.=standard deviation
[a]Categories are based on the International Standard Classification of Education (ISCED)(36)

Table 2. Word-categories of the DNT-II and the number of items per category

Category	N	Mean age of acquisition[1]	Word frequency[2]
EHF	25	< 5 years (Early)	High (> 50 words/million)
EMF	17	< 5 years (Early)	Mid (> 5 words/million < 50 words/million)
ELF	14	< 5 years (Early)	Low (< 5 words/million)
LHF	13	> 5 years (Late)	High (> 50 words/million)
LMF	13	> 5 years (Late)	Mid (> 5 words/million < 50 words/million)
LLF	17	> 5 years (Late)	Low (< 5 words/million)

Note.
E=Early Age of Acquisition of words (i.e. < 5 years); L=Late Age of Acquisition of words (i.e.> 5 years)
HF=High word frequency (>50 occurrences per million); MF = Mid word frequency (5-50 occurrences per million); LF = Low word frequency (<50 occurrences per million)
N: number of items per word category
[1]Values based on the ONLINE WORD LIST
Values derived from the SUBTLEX database

Table 3. DNT-II: Analysed 92 items and percentage of correct answers

Table removed due to further test development

Table 4. Difference between mean ranks of mean latency of age of acquisition of words (AoA) combined with word frequency

	All Participants (N=30)				Age Group I (N=15)				Age Group II (N=15)			
Word group	Mean rank of mean latency	*U-statistic*	*Z*	*p*	Mean rank of mean latency	*U-statistic*	*Z*	*p*	Mean rank of mean latency	*U-statistic*	*Z*	*p*
EHF-EMF	19.19-21.18	167.0	-0.556	.571	18.82-21.53	161.0	-0.736	.462	19.41-20.76	174.0	-0.368	.713
EHF-ELF	15.82-22.71	95.0	-1.191	.056	14.34-25.04	62.0	-2.985	**.003***	17.23-20.50	126.0	-0.909	.364
EHF-LHF	13.68-23.64	48.0	-2.788	.005	13.20-24.59	38.0	-3.170	**.002***	13.91-23.18	53.0	-2.597	.009
EHF-LMF	15.05-23.00	78.0	-2.219	.026	14.82-23.38	73.0	-2.390	.017	15.32-22.54	84.0	-2.014	.044
EHF-LLF	13.64-26.87	47.0	-3.650	**.000***	12.98-27.83	33.0	-4.083	**.000***	14.50-25.60	66.0	-3.063	**.002***
EMF-ELF	13.68-18.82	79.5	-1.568	.117	13.12-19.50	70.0	-1.945	.052	14.76-17.50	98.0	-0.834	.405
EMF-LHF	11.09-19.77	35.5	-2.729	.006	11.24-19.55	38.0	-2.611	.009	10.53-20.64	26.0	-3.175	**.001***
EMF-LMF	12.82-19.00	65.0	-1.904	.057	13.38-18.27	75.0	-1.486	.137	12.12-19.92	53.0	-2.406	.016
EMF-LLF	11.00-22.73	34.0	-3.531	**.000***	11.41-22.27	41.0	-3.266	**.001***	11.00-22.73	34.0	-3.531	**.000***

Note.
E=Early Age of Acquisition of words i.e. < 5 years; L=Late Age of Acquisition of words i.e.> 5 years
HF=High word frequency (>50 occurrences per million); MF = Mid word frequency (5-50 occurrences per million); LF = Low word frequency (<50 occurrences per million);
***=Asymp. Sig. (2-tailed): .003** (Bonferroni correction)

Continued Table 4. Difference between mean ranks of mean latency of age of acquisition of words (AoA) combined with word frequency

	All Participants (N=30)				Age Group I (N=15)				Age Group II (N=15)			
Word group	Mean rank of mean latency	*U-statistic*	*Z*	*p*	Mean rank of mean latency	*U-statistic*	*Z*	*p*	Mean rank of mean latency	*U-statistic*	*Z*	*p*
ELF-LHF	11.36-15.09	54.0	-1.259	.208	12.29-13.91	67.0	-0.547	.584	9.93-16.91	34.0	-2.354	.019
ELF-LMF	13.36-14.69	82.0	-0.437	.662	14.75-13.19	81.0	-0.485	.627	11.64-16.54	58.0	-1.601	.109
ELF-LLF	11.64-18.13	58.0	-2.051	.040	12.36-17.47	68.0	-1.615	.106	10.96-18.77	49.0	-2.444	.015
LHF-LMF	13.64-11.54	59.0	-0.724	.469	13.86-11.35	57.0	-0.840	.401	13.50-11.65	60.0	-0.666	.505
LHF-LLF	11.50-14.97	60.5	-1.142	.253	10.77-15.50	53.0	-1.531	.126	13.41-13.57	82.0	-0.026	.979
LMF-LLF	11.77-16.87	62.0	-1.635	.102	11.15-17.40	54.0	-2.004	.045	13.65-15.25	86.0	-0.530	.596

Note.
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HF=High word frequency (>50 occurrences per million); MF = Mid word frequency (5-50 occurrences per million); LF = Low word frequency (<50 occurrences per million);
***=Asymp. Sig. (2-tailed): .003** (Bonferroni correction)

Table 5. Difference between mean ranks of mean latencies of early/late acquired words

AoA of words	N	*Mean rank of mean latency*	*U-statistic*	*Z*	*p*
		All participants			
Early AoA – Late AoA	53 - 39	36.40 – 60.14	501.500	-4.203	**.000***
		Age group I			
Early AoA – Late AoA	53 - 39	37.06 – 59.33	533.000	-3.955	**.000***
		Age group II			
Early AoA – Late AoA	53 - 39	35.61 – 61.29	456.500	-4.559	**.000***

Note.
E=Early Age of Acquisition of words i.e. < 5 years; L=Late Age of Acquisition of words i.e.> 5 years
N=number of words
***=Asymp. Sig. (2-tailed): .05**

Table 6. Difference between mean ranks of mean latencies of high/mid/low word frequency

		Mean rank of mean latency	*U-statistic*	*Z*	*p*
Word frequency	N				
		All participants			
HF-MF	33-30	31.56 – 32.48	480.5	-0.200	.842
HF-LF	33-29	26.17 – 37.57	302.5	-2.483	**.013***
MF-LF	30-29	24.68 – 35.50	275.5	-2.418	**.016***
		Age group I			
HF-MF	33-30	31.23 – 32.85	469.5	-0.351	.726
HF-LF	33-29	24.11 – 39.91	234.5	-3.443	**.001***
MF-LF	30-29	23.68 – 36.53	245.5	-2.873	**.004***
		Age group II			
HF-MF	33-30	32.20 – 31.78	488.5	0.089	.929
HF-LF	33-29	28.92 – 34.43	393.5	-1.199	.230
MF-LF	30-29	26.96 – 33.19	342.5	-1.403	.161

Note.
HF=High word frequency (>50 occurrences per million); MF = Mid word frequency (5-50 occurrences per million); LF = Low word frequency (<50 occurrences per million)
N=number of words
***=Asymp. Sig. (2-tailed): .017** (Bonferroni correction)

Table 7. Explained variance on latency of AoA and word frequency

	N	AoA and WF combined	AoA	WF
All participants	30	25.9%	19.4%	8.6%
Age group I	15	30.1%	17.2%	14.8%
Age group II	15	24.3%	22.8%	-

Note.
N= Number of participants
AoA=age of acquisition of words
WF=word frequency

Table 8. Difference between mean ranks of mean latency of age group I and II within the same word subgroup

	Age group I	Age group II			
word group	Mean rank of mean latency	Mean rank of mean latency	*U-statistic*	*Z*	*p*
EHF	17.43	27.57	130.5	-2.617	**0.009***
EMF	14.59	20.41	95.0	-1.705	0.088
ELF	14.57	14.43	97.0	-0.046	0.963
LHF	7.91	15.01	21.0	-2.594	**0.009***
LMF	10.69	16.31	48.0	-1.872	0.061
LLF	14.93	16.07	104.0	-0.353	0.724

Note.
E=Early Age of Acquisition of words i.e. < 5 years; L=Late Age of Acquisition of words i.e.> 5 years
HF=High word frequency (>50 occurrences per million); MF = Mid word frequency (5-50 occurrences per million); LF = Low word frequency (<50 occurrences per million)
Asymp. Sig. (2-tailed): .05