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THESIS

Verbal Fluency: The right way to measure?

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ABSTRACT

Verbal Fluency is a means of measuring the ability of a person to organize their thinking. A population in which these problems in organization of thinking have been reported is Type 2 diabetes mellitus.

Until now the most common way to measure Verbal Fluency was the total amount of words. It is argued that the total amount of words does not measure the processes underlying performance on Verbal Fluency. In the current study the database form the Utrecht Diabetic Encephalopathy study (UDES) was used and this time the performances of the 190 respondents were reviewed in a different way in order see if the underlying processes could be measured. Performances were reviewed by means of clustering, switching and time. Results show that the new means of measuring for both semantic and phonological fluency only shows differences after a period of time and that the new means of measuring does not correlate with neuropsychological tasks that measure memory and executive functioning.

INTRODUCTION

Worldwide, Verbal Fluency (VF) tasks are used to examine cognitive functioning. Performance on this task is thought to depend on cognitive processes, such as the ability to search for and retrieve information, an efficient strategy use and attention (Hurks, Schrans, Meijs, Wassenberg, Feron & Jolles, 2010). The VF test is commonly used to evaluate the integrity of these executive functions and memory functions. Simply put this task provides a means of finding out whether and how well someone can organize their thinking (Pihlajamaki, Tanila, Hanninen, Kononen, Laasko, Partanen, Soininen & Aronen, 2000). The task requires people to generate as many words as possible beginning with a specified letter (phonemic fluency) or to name words from a specified semantic category (semantic fluency), all within an allotted period of time. Performance of the task depends on retrieval of words from long term storage and executive control of the process. VF tasks are sensitive to the presence of most forms of brain damage, traumatic brain injury, diffuse cerebral illness and neurodegenerative disorders (Abwender, Swan, Bowerman & Connoly, 2001) and is therefore a commonly used neuropsychological test.

Verbal Fluency Test's (VFT) are considered to assess mostly frontal lobe function. This is supported by functional imaging studies which demonstrate activation during VFT's, in the left frontal cortex corresponding to Broca's area, in the dorsolateral prefrontal cortex, pre motor cortex and the cerebellum. These studies used mainly phonological fluency. Based on neuropathological and psychological findings in early Alzheimer's disease, the assumption can be made that medial temporal lobe function is necessary for retrieving semantically associated words, which is needed in the semantic fluency task (Pihlajamaki et. al, 2000). These studies

show that phonological fluency mainly lies in the frontal lobes and semantic fluency relies on MTL function.

Most studies define VF task performance as the total numbers of words produced within a limited set time and category. It has been argued, however, that this scoring method does not provide information about the processes underlying performance on the VF tasks (Troyer, 2000). Recent experiments have shown that a more direct insight in the processes and interconnections, underlying VF task performance, can be derived by studying (a) the pattern of correct responses as a function of time and/or (b) measures of systemic organization of information, such as word clustering (Hurks et. al, 2010). The ability to create clusters, including producing subcategories, is dependent on verbal memory and word storage. The ability to shift between clusters, depends on cognitive abilities such as strategic search, set shifting and cognitive flexibility (Koren, Kofman & Berger, 2005). The ability to produce clusters (for example pets or farm animals) and the ability to efficiently shift between clusters (Koren et al., 2005), underlie optimal fluency (Troyer, Moscovitch & Wincour, 1997). In a different study by Troyer, Moscovitch, Wincour, Alexander & Stuss (1998) it was shown that frontal lesions show impaired switching with phonemic fluency and temporal lobe lesions show impaired clustering in semantic fluency. This combines the underlying abilities mentioned by Troyer et. al (1997) and the brain regions involved mentioned by Pihlajamaki et. al (2000).

In line with the information stated above, several investigators have observed that words tend to be produced in semantic clusters on semantic fluency tasks and in phonemic clusters on phonemic fluency tasks. Clusters are defined as burst of words over time that are semantically or phonemically related. There is pattern of responding, which suggests a two process model involving (a) a search for semantic subcategories followed by (b) an output mechanism to produce as many words as possible from the

subcategories (Troster, Fields, Testa, Paul, Blanco, Hames, Salmon & Beatty, 1997).

The production as a function of time before mentioned by Hurks et al. (2010), hasn't received much attention. Recent observations indicate that in comparison with three different groups of participants, namely depression, schizophrenia and normal, the response level on the VF task decreased as a function of time, with production being higher in the first time slice (Crowe, 1998).

From the former information could be said that systematical organization, such as clustering of words, and word production as a function of time, are possibly more adapt to measure the underlying processes of performance on the VF test.

With regard to the underlying processes stated above, analysis of word production by breaking the list of words into clusters of words which share similar properties, can shed light on the ability of recollecting associated words and when necessary the ability to switch to new categories. The process of clustering entails searching for categories of associated words, retrieving items from the category and then switching to a new category, when retrieval from the previous category fails. It has been argued that semantic clustering is a more automatic, relying on common rules of categorization (e.g., pets, farm animals), whereas phonological clustering is more laborious. The ability to switch between clusters can be measured by the total number of clusters. The total *number of clusters* can therefore be seen as a measure of cognitive flexibility. Cluster *size* on the other hand is seen as an indicator for the retrieval ability. Clustering seems to predict not only search strategies, but also the ability to retrieve and switch when retrieval from a previous category fails (Koren et. al, 2005). The ability to form clusters, including the production of words in the subcategories, relies on working memory and storage, which is mediated by the temporal lobe. The ability to shift/switch relies on cognitive processes, such as search

strategies, cognitive flexibility and executive functioning, which are mediated by the frontal lobe. Clustering is associated with the temporal lobe and switching is associated with the frontal lobe (Troyer et. al, 1997).

In this study age and education will also be taken into account to play a role in the performance on the VF task. Expectations are that education will play a role in the sense that the higher the education, the higher the performance will be. Age is expected not to play a role in performance. These assumptions are based on the findings by a study by Auriacombe, Fabrigoule, Lafont, Amieva, Jacqmin-Gadda and Dartigues (2001) that education had an influence on fluency. The higher the education, the higher the score on fluency and this effect was stronger for phonological fluency then for semantic fluency. Numerous studies have shown that cognitive processes underlie performance on VF. In the current study the relation of the processes with other cognitive test will be examined.

A clinical population in which problems in 'organization of thinking' have been reported is Type 2 diabetes mellitus (T2DM), a highly prevalent metabolic disorder, especially in older people and is characterized by high blood glucose levels. The primary aim of treatment of patients with T2DM is to maintain normal levels of glucose, in order to prevent several complications such as nephropathy, retinopathy and neuropathy. In the past decades it has become increasingly evident that diabetes also affects the central nervous system in several ways. This complication is referred to as 'diabetic encephalopathy'. Numerous studies have evaluated the neuropsychological functioning of individuals diagnosed with T2DM. The most common finding is that diabetes is associated with mild to moderate impairments of cognitive functioning with lowered performance on tests of speed of information processing, episodic memory and on tests of mental flexibility. The domains that are most affected are attention and executive functioning, specifically the sub domains verbal fluency and concept shifting, information processing speed and memory (van den Berg, 2009).

Impairment in verbal fluency is a common finding in T2DM, but so far only the total number of words for both semantic and phonological fluency was examined, a quantative measure, indicating possible impairments in mental flexibility and search strategies. However, the processes underlying this impairment, for example by examining differences in clustering, switching or production of words as a function of time, a more qualitative measurement, has not been examined in sufficient detail. This is unfortunate, since it has been described that patients with T2DM have particular difficulty to efficiently process unstructured information (Brands, JINS, 2007). The present study therefore examined the following research questions: *Are clustering, switching and time better measures to examine difference in VF in T2DM patients in comparison with normal controls? And if so, can these results be related to other cognitive tests?*

METHODS

Research participants

The database used for this study, is part of the Utrecht Diabetic Encephalopathy study (UDES). The UDES is a cross sectional, population based study on determinants of impaired cognition in diabetes mellitus in older adults. For inclusion in the study, patients had to be 55 to 80 years of age, functionally independent and Dutch speaking. Patients with T2DM had to have a minimal diabetes duration of 1 year. Other neurological or psychiatric disorders that could influence cognitive functioning, as well as a history of alcohol or substance abuse were exclusion criteria. For this study there were 190 respondents of which 126 had type 2 diabetes and 64 respondents for the control group.

Neuropsychological assessment

In the original study all participants performed a comprehensive neuropsychological test battery that consisted of eleven tests with 20 test indices. These tests were performed twice, at baseline and follow up four years later. The tests covered the major cognitive domains and were sensitive enough to detect small to moderate differences in cognitive ability. The major domains in the study were *abstract reasoning, memory, information processing speed* and *attention and executive functioning.* Within the domain *attention and executive functioning*, the verbal fluency was tested. For this study, performances on the VF tasks, the 15 words task (*memory)*, the Location Learning Test (*memory*), the Brixton Test (*attention and executive functioning)* and the Trail Making Test (*information processing speed, attention and executive functioning)* were used. Table 1 is an overview of how many respondents are in baseline and follow up for the tests used in the current study.

Table 1. Overview of the participants in baseline and follow up

	Baseline	Follow up
	N	N
Fluency_lett	181	109
Fluency_dier	180	109
NLV_IQ	178	107
WT_tot	187	109
LLT_6	189	109
TMT_BA	183	109
Brixton	183	108

Verbal Fluency task

The fluency task consists of 2 parts, namely semantic and phonological fluency. The first part is the phonological fluency. People are required to generate as many words as possible beginning with the letter *N*, within the allotted time of one minute. Next the task requires people to generate as many words as possible beginning with the letter *A*, again within the allotted time of one minute. The second part of the VF task is the semantic fluency. This task requires people to name words from a specified category, namely animals. The allotted time for the semantic fluency is two minutes.

In this study the data consists of the performances on the VF tasks. In the original study total amount of words was used as a measure, in this study time, switching and clustering will also be used as a measure.

The outcomes are retrieval, flexibility, overall fluency and time. Retrieval is measured by *'number of words'* and *'cluster size'*. Flexibility is measured by *'number of clusters'* and the overall fluency is measured by *'total number of words'*. Time is only measured in semantic fluency. In this task of VF a distinction is made between the total amount of words generated in the first minute and the total amount of words generated in the second minute.

A semantic cluster was defined as two or more successive words belonging to a specific subcategory, such as pets or farm animals. A phonological cluster was defined as two or more successive words corresponding to the following rules: (1) words beginning with the same first two letters (arm and art), (2) words beginning with two identical consonants (sight and sought), (3) words that rhyme (sand and stand) and words that are homonyms (some and sum). The cluster size was measured by counting the words within a cluster, omitting the first word in that category. So a group of 4 words belonging to the same subcategory had a cluster size of three. The mean cluster size was measured by dividing the cluster sizes by total amount of clusters. Switching was defined as the total number of cluster minus one.

Statistical analysis

Group differences

Between-group differences in the X fluency outcome measures was performed with analysis of variance. The variables being measured where: total amount of words, clustering, switching and cluster sizes in semantic and phonological fluency, estimated IQ, 15 Woorden Test, Location Learning Test, Brixton test and the Trail Making Test.

For the variable time an ANOVA and a t test were performed in order to see if there was a difference in the first minute and the second minute in the semantic fluency, and if so, if there was a significant difference between the two groups.

In order to find out if there was a difference between baseline and follow up, an ANOVA was performed for the semantic and phonological fluency. For semantic fluency at baseline there were 180 participants and at follow up 109. At baseline there were 181 participants for phonological fluency and at follow up 109.

A paired sample t test was performed in order to see if there was a difference between baseline and follow up, for the total score on semantic and phonological fluency, clustering, switching and cluster size.

Correlation

Correlation is used to explore if there is a relationship between variables and to describe the strength and direction of the relationship between two variables

Correlation was used to measure the relationship between age, education and the total score on semantic fluency and phonological fluency. Correlation was also measured for semantic fluency, phonological fluency and clustering, switching and two memory tasks and two tasks of executive functioning. Here by the assumption was made that the total number of clusters is related to executive functioning and cluster size is related to memory. Furthermore a distinction was made between the total group (T2DM and controls) and the diabetic group.

RESULTS

Characteristics

In this study there were 190 participants, 64 participants were in the control group and 126 patients with Type 2 diabetes mellitus were in the other group. Of all the participants 50% was male. The average education level was 4 according to Verhage, which is lower then MULO/MAVO. Of the participants the average estimated IQ was 99.20 (sd=15.1) and the average age was 65.4 years (sd=5.7).

Qualitative Analysis

For this study the performance on the VF tasks of the 190 respondents were reviewed. The total amount of words produced on the phonemic and semantic fluency were reviewed by different means. This time the words were clustered.

A few things stood out in the process. With the exception of a few respondents, more words were produced in the semantic fluency then in the phonological fluency. Typical subcategories stood out, like house pets for example dog, cat, rabbit, but also exotic animals like tiger, lion and elephant came across very often.

A strategy that a lot of people seemed to choose was to name all of the animals they knew within one subcategory, like fish or birds.

For the phonological fluency there did not seem to be a major difference in total amount of words produced. Overall the words produced seemed to be evenly distributed between the letters.

Statistical analyses

Group Differences

The phonological and semantic fluency tasks were compared to different variables; total number of cluster, total number of switches, cluster sizes and two memory tasks and two executive functioning tasks and last the estimated IQ. Table 2 shows the variables that differed significantly.

The total amount of words in the phonological (letter) fluency task is significantly different between the control group and the diabetics (p=0.036). Controls produce more words on the letter fluency then the type 2 diabetes mellitus patients.

The performances on both of the memory tasks differ significantly between the controls and the diabetic group (WT_tot: p=.050; Brixton p=.015). Controls perform better at the memory tasks then the diabetics do.

None of the other variables differ significantly between the controls and the type 2 diabetes mellitus group.

Table 2. Differences between T2Dm and controls

	Controls	**T2DM**
Fluency_letter	11.71 ± 4.37**	10.27 ± 4.36
Clustersize_Letter	0.44 ± 0.39	0.39 ± 0.30
Clusters_letter	8.27 ± 3.23	7.44 ± 3.00
Switch_letter	7.36 ± 3.18	6.44 ± 3.00
Fluency_dier	33.87 ± 7.22	32.79 ± 9.10
CLustersize_dier	1.16 ± 2.04	0.90 ± 0.51
Clusters_dier	9.23 ± 2.70	8.81 ± 2.10
Switch_dier	8.23 ± 2.70	7.85 ± 2.10
WT_Tot	42.03 ± 11.44**	38.55 ± 9.85
Brixton	18.60 ± 7.07**	21.43 ± 7.56

Data are presented as mean ± SD, unless otherwise specified, ** $p < .05$

Time was also a variable in this study. An ANOVA was performed to see if there was a difference between the total amount of words produced in the semantic fluency task, where a distinction was made between the amount of words produced in the first minute and the amount of words produced in the second minute. Result show that the difference between the amount of

words produced in the first minute and the second minute, differ significantly from each other (Min 1: $p<0.0001$; Min 2: $p<0.0001$). When the distinction was made between the two groups, significant difference were also found for minute 1 and 2 for controls (Min 1: $p<0.0001$; Min 2: $p<0.0001$) and for the T2DM group (Min 1: $p<0.0001$; Min 2: $p<0.0001$).

Between the two groups no significant differences were found (Minute 1: $p=0.326$; Minute 2: $p=0.373$).

Table 3. Time as a variable

	Minute 1	Minute 2
Total group	21.64 ± 5.14**	11.38 ± 4.84**
Controls	22.16 ± 4.09**	11.83 ± 4.71**
T2DM	21.37 ± 5.62**	11.15 ± 4.91**

Data are presented as mean ± SD, unless otherwise specified, ** $p < .05$

In the original study participants were measured twice, baseline and follow up. A paired sample t test was performed to examine if there were differences between baseline and follow up for semantic and phonological fluency. Table 4 shows the significant differences between baseline and follow up.

For semantic fluency there was no significant difference between diabetics and controls (Baseline $p=0.368$, Follow up $p=0.304$). For phonological fluency there was a significant difference between diabetics and the controls at baseline ($p=0.028$). Controls generated more words on the phonological fluency task then the diabetics. At follow up there was no significant difference between controls and diabetics ($p=0.091$).

Table 4. Differences baseline and follow up

	Controls	DM2
Baseline		
Semantic	33.87 ± 7.22	32.67 ± 9.16
Phonological	11.71 ± 4.37	10.19 ± 4.43
Follow up		
Semantic	33.36 ± 8.96	31.32 ± 9.92
Phonological	11.06 ± 3.92	9.67 ± 4.30

Data are presented as mean ± SD, unless otherwise specified

To compare the means for the variables semantic fluency, phonological fluency, number of switches, cluster sizes and number of clusters, a paired sample t test was performed. A distinction was made between the total group (controls and diabetics) and the diabetic group. In table 5. all means and SD are displayed.

Total group (dm2 and controls):

For the total group there is a significant difference between baseline and follow up for the total amount of words generated in phonological fluency (p=0.011), the number of switches (p=0.016) and the number of clusters made ($p < 0.0001$) in phonological fluency. There was also a significant difference between baseline and follow up for the total amount of words generated in semantic fluency (p=0.007) and for the number of clusters made in semantic fluency (p<0.0001).

Seen over a period of time (four years) the total amount of generated words for phonological fluency, the total amount of clusters and switches made in the phonological fluency declines. The total amount of words generated in the semantic fluency and the total amount of clusters made in the semantic fluency also declines.

Dm2 group:

For the participants with type 2 diabetes mellitus there is a significant difference between baseline and follow up for the total amount of clusters made in phonological fluency ($p<0.0001$), the total amount of words generated in the semantic fluency ($p=0.001$) and the total amount of clusters ($p<0.0001$) and switches made ($p=0.005$) in the semantic fluency.

Seen over a period of time (four years) the total amount of clusters made in the phonological fluency, the total amount of words generated in the semantic fluency and the total amount of clusters and switches made in the semantic fluency also declines for the participants with diabetes.

Table 5. Variable differences baseline and follow up (dm2+controls)

	Baseline	Follow up
TOTAL GROUP		
Fluency_letter	11.6 ± 4.66	10.27 ± 4.15
Cluster_letter	7.9 ± 3.30	2.9 ± 1.88
Switch_letter	7.0 ± 3.28	6.4 ± 2.91
Fluency_dier	33.9 ± 8.97	32.0 ± 9.50
Cluster_dier	9.0 ± 2.24	7.4 ± 3.31
T2DM GROUP		
Cluster_letter	7.4 ± 3.21	2.7 ± 1.83
Fluency_dier	34.02 ± 9.88	31.09 ± 9.82
Cluster_dier	9.15 ± 2.02	7.4 ± 3.52
Switch_dier	8.15 ± 2.02	7.34 ± 2.20

Data are presented as mean ± SD, unless otherwise specified

Correlations

To describe the relationship between semantic fluency, phonological fluency, age and education, a test for correlation was performed. Semantic

and phonological fluency are significantly correlated). It is a positive correlation (r=0.524, p<0.0001). There is a significant positive correlation between phonological fluency and education (r=0.444, p<0.0001) and a significant positive correlation between semantic fluency and education(r=0.332, p<0.0001). No significant correlation was found for age and both semantic (r=-0.058, p=0.437) and phonological fluency (r=-0.016, p=0.831).

In order to find out if there is a relationship between memory tasks and cluster size and tasks of executive functioning and total number of clusters, a test for correlation was also performed. Correlation was performed for the total group (diabetics and controls).

Memory and fluency

Total group: Diabetics and controls

Table 6 shows that for the phonological and semantic fluency task, cluster size does not have a significant correlation with either of the memory tasks. These results might imply that both the phonological and semantic fluency task do not measure the same underlying processes as the memory tasks do.

Table 6. Memory and fluency

	WT_tot	LLT_tot
Clustersize_letter	.089	.097
Clustersize_dier	.050	-.060

** p < .001 (2 tailed)

Executive functioning and fluency

Total group: Diabetics and controls

Table 7 shows that for the phonological and semantic fluency task, total amount of clusters don't have a significant correlation with either of the

executive functioning tasks. These results might imply that both the phonological and semantic fluency task do not measure the same underlying processes as the executive functioning tasks do.

Table 7. Executive functioning and fluency

	TMT_BA	Brixton
TotCluster_letter	-.005	-.002
TotCluster_dier	.043	-.044

** $p < .001$ (2 tailed)

DISCUSSION

Performance on the VF task is thought to depend on cognitive processes such as executive functioning and memory (Hurks et. al, 2010).

It has been argued that the total number of words produced, does not provide information about these underlying processes (Troyer, 2000). A more direct insight in the underlying processes can be derived by studying the pattern of correct responses as a function of time and/or measures of systemic organization of information, such as word clustering (Hurks et. al, 2010).

A clinical population in which problems in 'organization of thinking' have been reported is Type 2 diabetes mellitus. The domains most affected are attention and executive functioning and mainly the sub domains verbal fluency and concept shifting, information processing speed and memory (van den Berg, 2009).

Impairment in verbal fluency in T2DM has been found, but until now only the total number of words was examined. Patients with T2DM have particular difficulty to efficiently process unstructured information and for this reason this study examined if a more structured way of measuring, by means of clustering, switching and time as a function, are better measures to examine the difference in VF between T2DM and controls.

A quantative way of measuring is the total amount of words. Statistical analyses shows that the total amount of words generated in the phonological fluency significantly differed between T2DM and controls, in which controls perform better. Phonological fluency lies in the frontal lobes (Pihlajamaki et. al, 2000) and it is said that cognitive flexibility and executive functioning is mediated by the frontal lobes. So the difference in performance might be explained by an impaired executive functioning, which in its turn makes shifting and having the right search strategy more difficult.

Clustering, cluster sizes, number of switches and time are a more qualitative way of measuring. Clustering, cluster sizes and number of switches made were not significantly different between T2DM and the controls. Expectations were that a difference exists between the two, because findings are that T2DM are impaired at processing unstructured information (van den Berg, 2009). Time was only analyzed in the semantic fluency task. Results show that there was a significant difference between the total amount of words produced between the first minute and the second minute. There wasn't a significant difference between T2DM and controls. So the controls and the T2DM patients produced about the same amount of words, with more words in the first minute and less words in the second minute. These findings are in accordance with a study by Crowe (1998), which showed that for three different groups (depression, schizophrenia, normal) the response level decreased as a function of time, with production being higher in the first time slice. Based on results stated above, it might be that the more qualitative analysis does not measure aspects that are missed by the standard measure of total amount of words.

In this study age and education were taken into account to play a role in the performance on the VF tasks. Education has a positive relationship with semantic and phonological fluency. The higher the education, the more words that are generated. The effect was stronger for phonological fluency then for semantic fluency, this in accordance with the findings in the study by Auriacombe et. al (2001). For age no significant relationship was found.

The total number of clusters can be seen as a measure of cognitive flexibility and cluster size is seen as an indicator for the retrieval ability (Koren et. al, 2005). In order to see if this relationship can be found in the current study, number of clusters is compared to tasks for executive functioning and cluster size compared to memory tasks. Analyses shows that cluster size on both semantic and phonological fluency had no significant correlation with

either of the memory tasks. The cluster size in both phonological and semantic fluency does not appear to measure the same underlying processes as the memory tasks do. Analyses also show that the total amount of clusters on both phonological and semantic fluency had no significant correlation with either of the executive functioning tasks. The total amount of clusters on both phonological and semantic fluency does not appear to measure the same underlying processes. It would seem that the number of clusters isn't a measure for cognitive flexibility.

In the original study the participants were measured on two occasions, within the time span of 4 years. Performance on both measurement points can be compared in order to see if there is a difference in performance. Expectations were that the performance of T2DM patients would decline because of the 'diabetic encephalopathy'.
The semantic fluency task showed no significant difference between baseline and follow up. Semantic fluency relies on medial temporal lobe function and is related to memory function. These results show that the underlying processes involved were not impaired between baseline and follow up. For the phonological fluency there was a significant difference between controls and T2DM at baseline. Controls performed better than the diabetics. This difference wasn't seen at follow up. After the time period of 4 years, the performance of controls and diabetics was about the same. This might imply that the underlying processes involved are more impaired for controls after the four years. The expected decline in impairment in the performance of the T2DM patients wasn't seen.

Semantic fluency, phonological fluency, number of switches, cluster sizes and number of clusters were also compared between baseline and follow up. Seen over a period of time (four years) the total amount of words generated for phonological fluency, the total amount of clusters and switches made in the phonological fluency declined. The total amount of words generated in

the semantic fluency and the total amount of clusters made in the semantic fluency also declined for the whole group (T2DM and controls). When T2DM were taken apart for analyses, the total amount of clusters made in the phonological fluency, the total amount of words generated in the semantic fluency and the total amount of clusters and switches made in the semantic fluency also declines, seen over a period of time.

The ability to create clusters, including producing subcategories, is dependent on verbal memory and word storage. The ability to shift between clusters depends on cognitive abilities such as strategic search, set shifting and cognitive flexibility (Koren et. al, 2005). So the results stated above, show that for the total group and the diabetics, for semantic as well as phonological fluency performance declined and this might also imply that the underlying processes involved such as memory and executive functioning might also have declined.

In this study a difference was found for phonological fluency and for time in the semantic fluency, but no differences were found for clustering, switching and the total number of words in both semantic and phonological fluency. Between baseline and follow up differences in clustering, switching and total number of clusters were found. A more qualitative way of measuring does seem to find differences in performance only over a period of time, but the underling processes it says to measure were not found. Yes the performance can be broken up in smaller abilities, such as clustering and switching, but to say that it pin points the underlying processes of performance, no. Is it therefore a wise decision to make a distinction in total amount of words, clustering, cluster sizes and switching? Maybe at the individual level. At an individual level it could show if the problem is that a person cannot switch between subcategories or if someone simply can't retrieve words from memory. One could conclude that it is a qualitative way of measuring verbal fluency. It might be helpful at breaking down the

performance at an individual level and give a glimpse at the subtle processes and/or strategies used.

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