Idiom comprehension in Attention-Deficit/Hyperactivity Disorder

A preliminary study

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Abstract

Idiom comprehension was assessed in a group consisting of three adults diagnosed with AD/HD and a control group consisting of three adults without any known disorder. We tested whether the AD/HD group had more difficulties regarding idiom comprehension with three tasks: a picture-selecting task, a task where both groups had to give a definition of a given idiom, and a task where they had to match an idiom to the correct story. We found no significant results: a diagnosis of AD/HD did not seem to have any effect on the performance on these tasks.

Keywords: AD/HD, idioms, idiom comprehension, brain damage, language impairment

1.0 Introduction

One of the most striking features of human language is figurative language; one can utter a sentence in which the literal interpretation is not what is implied. Instead, the hearer must go beyond that literal interpretation and has to decode the actual meaning of the utterance. This task seems daunting, but most individuals will understand the non-literal meaning of the utterance, if, at least, the utterance is familiar or if the meaning of it is decompositional; it can be derived from the individual parts of the utterance. (Cacciari and Tabossi, 2014). Figurative language can be subdivided among other things into metaphors, hyperboles, proverbs and idioms. These types of figurative language are, however, not homogeneous; they all have different characteristics and traits. One approach to classify non-literal language is the distinction between *salient* (or fossilized) and *non-salient* (or novel) non-literal expressions, where the former is relatively frequently used in everyday speech, while the latter is not. Goira (2003) and Glucksberg (2003) have shown that the cognitive processes between salient and non-salient non-literal expressions differ, however, why this is the case is still unknown.

Perhaps the most frequent form of figurative language in everyday speech are idioms, expressions where the meaning cannot be derived from the usual meaning of their constituent elements. It has long been thought that idioms are frozen, “dead” metaphors, and that their meaning cannot be deduced from the meaning of their individual elements (Papagno et al., 2003; Rapp and Wild, 2011). Research on idioms has however shown that this is not the case; idioms can be complex and dynamic, their meaning is not fixed and can change over time.

The degree of transparency and compositionality of idioms are also important factors when it comes to understanding this type of figurative language. When an idiom is decomposable, the phrasal meaning can in some degree be related to the independent contribution of the idiom parts (Papagno et al., 2004). For instance, with an idiom like *geld over de balk smijten* (literally:

"*throwing money over the beam*"; throw money around), there is a correspondence between spending too much money and the individual idiom parts (throwing something over a beam). However, this particular idiom is not (completely) transparent. The meaning cannot be fully derived from the extent of the idiom configuration; in this instance, *geld over the balk smijten* is decomposable and opaque. This is, of course, not the only configuration possible; other idioms could just as well be non-decomposable and transparent, so that their meaning can be derived from the individual words an idiom consists of (Papagno et al., 2003). There is also a difference between ambiguous and non-ambiguous idioms; the former are idioms that have potentially also a literal meaning, while the latter are idioms that have no literal meaning available (Zempleni et al., 2007).

Furthermore, idioms undergo syntactic processing even when their figurative meaning has been activated (Peterson et al., 2001), and they are lexically flexible and productive (*button your lips* can be changed to *fasten your lips*, without losing its figurative meaning) (Gibbs, Nayak and Cutting, 1989; McGlone, Glucksberg and Cacciari, 1994). This suggests that idioms do not have a fixed configuration but that they are in fact flexible.

Two main theories are proposed when it comes to the understanding of idioms. One theory, the *lexical representation hypothesis*, suggests that idioms are being processed and represented in the mind as lexical items (Swinney and Cutler, 1979). The *configurational hypothesis*, however, contradicts this idea; it proposes that idioms are represented and processed as configurations of words. Whenever a configuration of words has gained enough activation, the corresponding meaning is selected (Cacciari and Tabossi, 2014). According to Gibbs and Colston (1999), the meaning of idioms cannot be derived from analyzing the meaning of the individual words making up the idiom; they are *conventionalized*. Although idioms are highly variable, with even some idioms having almost no constraints and are able to occur in varying constructions, they usually occur in limited syntactic constructions and allow very few syntactic operations (Fraser, 1970).

In the following sections, we will first discuss the findings with regard to the underlying neural mechanisms involved in idiom comprehension in individuals who are not afflicted with any disorder, after that we will discuss, among other things, previous research on disorders named above and their difficulties with idiom comprehension, along with the postulated underlying neural mechanisms involved. Subsequently, we will discuss the psychological population that has our particular interest in relation to idiom comprehension: Attention-Deficit/Hyperactivity Disorder (AD/HD) and its neural basis, to see if there are overlapping brain structures involved in idiom comprehension and that are impaired in AD/HD . Finally, we will report our pilot study about idiom comprehension in AD/HD.

2.0 Attention-Deficit/Hyperactivity Disorder

Attention-Deficit/Hyperactivity Disorder (AD/HD) is one of the most commonly found disorders in children; an estimated 3-5% of children suffer from this disorder **(**Berquin and Godefroy, 2010). Symptoms, as described by the *Diagnostic and Statistical Manual of Mental Disorder* (American Psychiatric Association, 2000), are inattention, hyperactivity and/or impulsivity, which lead to considerable problems in social, educational or work-related, and family settings.

The cause of AD/HD is still unknown, but many researchers have tried to identify contributing factors. Studies indicate that deficits at the level of executive function[1] may be the core problem of AD/HD (Berquin and Godefroy, 2010), where affected individuals have difficulties with planning, set shifting (the ability to shift attention from one task to another) and inhibition or suppression of responses. Other studies have shown that, when individuals afflicted with AD/HD were compared to a control group on the Wisconsin Card Sorting Test (WCST)[2], the results suggest that an underlying dysfunction of the inhibitory forebrain is at play (Chelune et al., 1986), which displays a resemblance to underlying problems of the frontal lobe syndrome.

Considering the domain of language, people suffering from AD/HD seem to have difficulties with pragmatics such as interrupting others and excessive talking, comparable to the difficulties observed in Autism Spectrum Disorder (ASS) (Parigger, 2012; Väisänen et al., 2015; Kim and Kaiser, 2000; Camarata and Gibson, 1999; Staikova et al., 2013). These pragmatic difficulties are ascribed to the fact that individuals suffering from AD/HD have no properly working executive functions. Tannock and Schachar (1996) state that executive functioning is furthermore important in the production and interpretation of language, and that, when individuals afflicted with AD/HD are put on stimulant medication, not only their behavioral symptoms improve, but their pragmatic symptoms as well.

However, when we look outside of the present literature on language problems observed in individuals with AD/HD and focus our attention on the social interaction with individuals suffering from AD/HD in our own lives, it seems that pragmatic difficulties are not the only difficulties prevalent. Based on these individuals, and one in particular[3], and our own observations, it seems that they also have difficulties in either producing or understanding figurative language, especially

1 Executive functions are a set of processes that involve mental control and self-regulation. These processes include attentional control, inhibitory control, working memory, cognitive flexibility, reasoning, problem solving and planning.

2 A psychological task to measure the ability to set shift, where a participant is presented with a number of stimulus cards. The participant must match the cards without knowing how to match them; he or she is only told when a match is wrong or right.

3 This observation is shared by the author of this thesis through personal experience, but not documented.

concerning idioms. The problem that stand out in this particular case is trouble with interpreting the correct meaning of idioms; in a lot of instances the idiom is taken too literal, which leads to communication problems, and producing the idiom correctly. One is likely to produce a few core elements of the idiom correctly, but mixes up some of the other elements such as "*In zak en puin zitten*" instead of "*In zak en as zitten*" (lit: sitting in bag and ashes, fig: being depressed, being down) or "*Je kunt het water naar de zee brengen maar niet het paard laten drinken*" instead of "*Water naar de zee dragen*" (lit: carrying water to the sea, fig: doing something useless) and "*Je kan een paard naar het water leiden, maar je kunt hem niet laten drinken*" (lit: you can lead a horse to water, but you cannot make it drink, fig: you cannot force someone to do something, even when you give them all the resources).

This has sparked our interest and, therefore, we try to investigate in this paper whether there might be an overlap between the observed difficulties in individuals with AD/HD and other atypical populations with regard to the comprehension of idioms. Multiple studies have shown that individuals afflicted with psychological disorders such as patients with Alzheimer's disease, aphasia, and unilateral brain damage, among others, experience trouble with comprehending idioms (Papagno, 2001; Papagno et al., 2004; Kempler et al., 1999)

2.1 Neural basis of AD/HD

Many brain areas are thought to be involved in the underlying cause of AD/HD. Some researchers argue that a dysfunction of the cerebello-thalamo-prefrontal circuit is the main problem underlying AD/HD, which leads to overactivity and deficits of inhibition, motor control, and executive function (Berquin and Godefroy, 2010). Other structural imaging studies implicate four cerebral regions in AD/HD; the basal ganglia, notably the caudate nucleus, the cerebellum, the (mainly) right prefrontal cortex, and the splenium of the corpus callosum (Berquin and Godefroy, 2010). A lower volume of the rostrum and rostral body of the corpus callosum, no normal left-right asymmetry in the anterior brain and caudate nuclei, and a smaller globus pallidus have also been found in children with AD/HD **(**Berquin and Godefroy**,** 2010). Another implicated brain circuit is the striato-prefrontal circuit. Imaging studies have shown that individuals with AD/HD have a decreased blood flow and metabolism in the anterior frontal regions and striatum **(**Berquin and Godefroy, 2010).

Brain regions involved in the different types of visual attention, such as selective attention[4],

4 The ability to select from many factors or stimuli and to focus on only one factor while filtering out other distractions (Mar et al., 2010).

divided attention[5] and sustained attention[6] which are implicated in individuals with AD/HD, are thought to be the frontal eye fields and midbrain superior colliculus for overt visual saccades (i.e., blinking of the eye) and covert attentional shifts, the lateral pulvinar of the thalamus for attentional engagement at a new locus, and the posterior parietal cortex for disengagement of attention with regard to selective attention (Mar et al., 2010). When considering divided attention, the brain region implicated seems to be the middle-dorsolateral prefrontal cortex (Mar et al., 2010).

When it comes to impulsivity, measured by the go/no-go task during functional imaging, bilateral activation within the inferior frontal cortex, anterior cingulate cortex, supplementary motor area, dorsolateral prefrontal cortex and inferior parietal cortex are found. However, the inferior frontal cortex, and especially the right inferior frontal cortex, seems to be critical to inhibition, while the other brain areas are implicated more strongly in maintaining a go response or error monitoring (Mar et al., 2010).

Not only the go/no-go task is used to measure impulsivity; tests using decision-making or impulsive choice are also frequently administered. Impulsive choice tasks, where one gets the choice between a small, immediate reward or a bigger, delayed reward, and where higher levels have been documented in individuals suffering from AD/HD, show that the brain areas involved are the lateral prefrontal and intraparietal cortical regions, independently of the delay of the reward, and the limbic regions including the ventral striatum and medial orbitofrontal cortex are activated by relatively immediate rewards **(**Mar et al., 2010).

2.2 Executive functioning in AD/HD

As mentioned before, Tannock and Schachar (1996) stated that impaired executive functioning is considered to be a contributing factor to AD/HD. What exactly embraces the term 'executive functioning' depends on the classic distinction between automatic and effortful processing (Happé et al., 2005): the former provides an efficient means of responding to routine situations, the latter is needed for adaptive responses to novel or complex situations and depends on a range of higher-order cognitive processes (such as set-shifting, inhibition, self-monitoring, and planning) (Pennington and Ozonoff, 1996). These are associated with the functions of the prefrontal cortex, most notably the dorsolateral prefrontal cortex (Dinn et al., 2010). Orbitofrontal hypoarousal is associated with behavioral disinhibition; as individuals with AD/HD have difficulties with inhibiting certain stimuli, it might be so that this is due to weak activation of the orbitofrontal cortex.

5 The ability to process two or more responses or to react to two or more different demands simultaneously (Mar et al., 2010).

6 The process of focusing on a particular object in the environment for a certain period of time (Mar et al., 2010).

3.0 Neural mechanisms implicated in idiom comprehension

According to Tabossi and Zardon (1993), the mental processes underlying the identification of idioms during spoken language comprehension differ from (spoken) word recognition. However, Sprenger, Levelt and Kempen (2006) claim that this is not the case. They propose that, because idioms are represented by their own lexical concepts (the words that make up an idiom), lemma's, and because these lemma's combine to form a superlemma, idioms are processed in the same manner as words. The exact mental processes or neural mechanisms underlying idiom comprehension and/or production in individuals without any known disorder have not yet been discovered. However, many studies such as those by Bohrn, Altmann, and Jacobs (2012), Bottini et al. (1994), Hillert and Buračas (2009) and others tried to do so, and while these studies gave multiple insights, no real consensus has been yet established. In this section, we will briefly discuss this issue.

It was previously thought that the right hemisphere was the crucial part for comprehending figurative language because research had shown that damage to the right hemisphere will impair figurative language. Kempler et al. (1999) argue that the right hemisphere is dominant for the processing of idiomatic expressions, mediated by the fact that idioms have three features that literal expressions do not possess and which makes them the best candidates for right-hemispheric processing - stereotyped form (the structural properties of expressions), conventional contextualized meaning (the more or less standardized meaning of an expression), and intrinsic affective content (the intrinsic emotions an expression elicits). These three features are preferred by the right hemisphere. The right hemisphere plays a role in processing whole forms without analyzing them, understanding contextual information and semantic inference, and processing emotional information (Bogen, 1969; Bradshaw and Nettleton, 1983; Bryden, 1982; Brownell, Potter, Bihrle, and Gardner, 1986; Molloy, Brownwell and Gardner, 1990, Cimino, Verfaellie, Bowers and Heilman, 1991; Gainotti, Caltagirone and Zoccolotti, 1993, Wechsler, 1973). However, studies using repetitive Transcranial Magnetic Stimulation (rTMS)[7] on the left hemisphere of controls have shown that disabling a proper functioning left hemisphere with rTMS will also impair the comprehension of figurative language **(**Oliveri, Romero and Papagno, 2004). More recently, it has been suggested by i.a. Huber-Okrainec et al. (2005) that there is a distributed neural system involved in idiom comprehension; processes that are required for idiom comprehension are located or distributed throughout the brain.

Brain imaging studies show that there are differences in activation for every type of non-

7 Repetitive Transcranial Magnetic Stimulation, a noninvasive method to stimulate the brain which can either help or hinder certain processes that take place in the brain during tasks.

literal expression in individuals without a brain injury; an idiom causes a different activation pattern in the brain than a metaphor does (Rapp and Wild, 2011). Both the right and left hemisphere play a role in figurative language comprehension, and for idiom comprehension, interhemispheric integration is necessary (Huber-Okrainec et al., 2005). Both the right and left hemisphere also are necessary to process relevant semantic information for discourse comprehension which is important for the understanding of figurative language, while propositional information is only processed in the left hemisphere (Long and Baynes, 2002).

A meta-analysis of neuroimaging studies with regard to figurative language (Bohrn, Altmann and Jacobs, 2012) supports this view; the studies discussed in this analysis found variation in the brain regions implicated. The study has evaluated 22 fMRI studies and found that, for figurative language, stronger activations were found in the left inferior frontal gyrus (BA[8] 45), extending to the anterior insular cortex, the right inferior frontal gyrus (BA 47), extending to the right superior temporal gyrus, the left middle temporal gyrus (BA 21/37), the medial frontal gyrus (BA 10/9), the left inferior temporal gyrus **(**BA 20/21) and the left amygdala. For literal language, strong activations were found in the medial bilateral precuneus/cuneus (BA 7/31), the right middle frontal gyrus (BA 8/9), and the right inferior parietal lobe (BA 40). Bohrn, Altmann and Jacobs (2012) state that this does not support the right-hemisphere hypothesis when it comes to figurative language comprehension; only one cluster of activation was found in the right hemisphere (inferior frontal gyrus peak in BA 45), while the other clusters were found in the left fronto-temporal lobes, with the largest region covering broad parts of the inferior frontal gyrus. This could be due to the fact that figurative language processing relies on the same network as literal language processing, but that figurative language requires more cognitive demands. For idiom comprehension, the meta-analysis found that it elicits robust activations in the left inferior frontal gyrus; the same area where part of metaphor comprehension takes place. However, for idiom comprehension, the activation is larger than for metaphor comprehension, and the activation spreads farther towards the dorsolateral prefrontal cortex. The right hemisphere also showed some activation during idiom comprehension, especially the right inferior frontal gyrus, but further analysis indicates that this might be due to enhanced attention to the salience, or how much one idiom stands out compared to others, of familiar idioms.

Functional imaging studies done by, i.a., Zempleni et al. (2007) have shown that, in idiom comprehension, the bilateral inferior frontal gyri and the bilateral middle temporal gyri displayed activation. Also, when aspects of idiom comprehension are concerned, both Brodmann's areas (BA) 45 and 47 are activated; they are postulated to be involved in semantic and pragmatic processing,

8 Brodmann Area, a method of mapping brain regions.

including having sensitivity to pragmatic and semantic violations. Furthermore, the left middle and inferior temporal gyri (BA 20 and 21) are involved in semantic retrieval, and when the need for semantic retrieval increases, there was also activation found in the right temporal lobe. Zempleni et al. (2007) likewise found in their study that, even though these areas are usually not implicated in language processing, the left cerebellum, left occipital lobe (cuneus and lingual gyrus) and the right inferior frontal gyrus (BA 13) were involved. Their results suggest that, even though both figurative and literal processing demand more activation in several brain regions when using cognitive resources, figurative language processing mostly recruits the language network (mainly the Broca's area, arcuate fasiculus and Wernicke's area loop). In their study, it was also found that unambiguous sentence comprehension elicited more activation (in the right insula (BA 13), left basal ganglia, left cerebellum, left precentral gyrus (BA 6)) than ambiguous sentences did, which might suggest that during idiom comprehension, both the literal and non-literal meanings are competing for selection, and the activation in the brain shows the suppression of the literal meaning. They conclude that idiom comprehension is supported by bilateral inferior frontal gyri and bilateral temporal gyri activation.

Not only these parts of the brain that support language functions are important for idiom comprehension, other parts that support the functioning of inhibition, an aspect of executive functioning ([dorsolateral] frontal lobe) also play a role, especially concerning ambiguous idioms (Papagno et al., 2003). Whenever one processes an ambiguous idiom, the literal meaning of this idiom needs to be adequately inhibited so that it will not interfere with the, genuine, figurative meaning. If successful inhibition fails, or when the inhibition is not adequate enough, it is possible that the literal meaning will be selected instead of the figurative meaning in question.

Another relevant factor in understanding language is interhemispheric integration, the process where information is exchanged between the two hemispheres. A study by Bottini et al. (1994) showed that, in controls, the literal comprehension of sentences activates the parietal cortex, the precuneus, the middle and inferior temporal gyri and temporal pole, and the prefrontal and basal frontal cortex of the left hemisphere. Figurative language comprehension activates approximately the same regions in the left hemisphere, together with the posterior cingulate, the precuneus, the middle temporal gyrus, and the prefrontal cortex in the right hemisphere. One of the most important structures in interhemispheric transfer is the corpus callosum. The anterior portion of the corpus callosum plays a role in transfer of higher-order cognitive skills, such as planning, and semantic language functions (Sidtis et al., 1981). The body of the corpus callosum and the splenium also seem to be important for interhemispheric transfer of language information (Funnell, Corballis, and Gazzaniga, 2000).

However, not everyone is capable of understanding the meaning of figurative language or able to produce figurative language, such as individuals suffering from autism, who take figurative language too literally (Tager-Flusberg, 2000); it turns out that in individuals with various mental/neurological disorders, figurative language comprehension is defective. With regard to the comprehension of idioms, individuals suffering from disorders such as Alzheimer's disease, aphasia, unilateral brain damage and so forth, are impaired (Papagno et al., 2001; Papagno et al., 2003; Papagno 2004; Kempler et al., 1999). Also, understanding figurative language is found to be more difficult for individuals suffering from right-hemispheric damage than for left-hemisphere damaged patients (Winner and Gardner, 1977). This seems to imply that the right hemisphere is involved in non-literal interpretation, and possibly in the production of figurative language.

4.0 Idiom comprehension in disorders

In the following section we will discuss idiom comprehension in disorders such as Alzheimer's disease, aphasia, corpus callosum agenesis and unilateral brain damage. We acknowledge that there might be more disorders where idiom comprehension is impaired, however, the aforementioned disorders are generally well-documented and described.

4.1 Alzheimer's disease

Alzheimer's disease is characterized by a continuous decline of cognitive functions, and is mostly prevalent in the elderly. The brain is degenerating over time, especially in the cerebral cortex (Alzheimer Nederland, 2015). Language problems are very common in Alzheimer's disease **(**Rapp and Wild, 2011) and are most notable in the domain of communication, semantics, and spontaneous speech, while the phonematic domain is preserved **(**Romero and Kurz, 1996).

There is very little literature on non-literal language comprehension in individuals with Alzheimer's disease. One study by Winner and Gardner (1977) showed that patients with dementia behaved like patients suffering from right-hemispheric damage; they had problems with interpreting non-literal meaning(s) and instead opted in most cases for a literal interpretation.

Papagno (2001) found that people with an early stage dementia[9] had no problems with language whatsoever; almost half of the participants had normal scores on all language tests, and figurative language seemed to be the least impaired language domain. There was also no decline in idiom comprehension found when the disease worsened; only metaphors showed a decline in comprehension.

9 Individuals with a score between 60 and 85 on the Milan Overall Dementia Assessment were considered as having early stage dementia. See Papagno (2001) for more details.

Papagno et al. (2003) also show that individuals suffering from Alzheimer's disease have a strong bias towards the literal interpretation of idiomatic expressions on a written task when the idioms were opaque; they have difficulties with suppressing this interpretation, and it is suggested that the activation of the literal meaning is stronger than the figurative meaning. However, on a verbal task, where the patients gave an oral explanation of the idiomatic expressions, the patients performed better compared to the written task, although they still displayed a stronger preference for the literal interpretation than for the figurative one.

Kempler et al. (1988) investigated 29 patients with Alzheimer's disease, where they found that those patients had a more severe deficit in understanding familiar expressions compared to the control groups. However, it must be noted that the study did not differentiate between idioms, where the literal meaning is often incomprehensible (for example: *to throw a wrench in the works*, meaning to do something that stops an event or activity from being successful), and proverbs, where the literal meaning is understandable but only makes sense when it is applied to a broader set of situations (*don't cry over spilled milk*, meaning don't get upset over something that's already done), and that the patients were also significantly impaired in comprehending literal control stimuli.

Rassiga et al. (2009) showed that patients with Alzheimer's disease were impaired in both selecting the correct meaning of an idiom when they had to choose between four words, and when the choice was between four pictures.

It seems that Alzheimer's disease patients do not experience many problems with idiom comprehension; as it turns out, only metaphor comprehension degrades when the disease progresses, while other language domains are not affected from the ongoing disease. The only problem found is the suppression of the literal meaning of an idiom, which could be due to the fact that Alzheimer's disease patients have degrading executive functioning skills.

4.2 Aphasia

Aphasia is a term used to describe language problems after brain focal injury, for example, when someone had a stroke. Individuals with aphasia experience problems ranging from having occasional trouble to find the right words, to even losing the ability to speak, read, or write. Intelligence however, is spared (Damasio, 1992).

Papagno et al. (2004) found that patients with left-hemispheric damage had a severely impaired understanding of idioms and a bias towards the literal interpretation of idioms, even when they were able to understand the individual words of these idioms. Their idiom comprehension was also impaired relative to the comprehension of literal expressions, also suggesting that idioms cannot be reduced to impairment of individual words or of sentences. It has been suggested that

aphasic patients have a greater involvement of the central executive, which often prevents adequate suppression of the literal meaning of an idiomatic expression, because of their damaged language processing resources (Papagno et al., 2004). Furthermore, they claim that idiom comprehension is not only subserved by the right hemisphere as was commonly thought.

Another study, done by Cacciari et al. (2006) examined the comprehension of ambiguous idioms, idioms with a well-formed literal counterpart, in aphasic patients. They found that the patients too had difficulties with the comprehension task compared to controls, and that non-ambiguous idioms – idioms that do not have an overt literal interpretation – were especially challenging, suggesting a simultaneous damage to linguistic processing and to the recognition of figurative language. Their research also shows that, at least in their participants, two brain sites are relevant for idiom comprehension, namely a frontal, subcortical area and a cortical temporal region. Nonetheless, they argue that these brain regions are not the brain regions for idiom comprehension per se. The task used in this investigation, a picture-selecting task, draws upon the central executive which has neural correlates in the frontal lobe.

4.3 Corpus callosum agenesis

A neurodevelopmental disorder called spina bifida meningomyelocele (SBM) is associated with agenesis and hypoplasia of the corpus callosum, where the former means that no or parts of the corpus callosum is present, and the latter where the corpus callosum is underdeveloped. Children who suffer from this disorder also seem to have trouble with discourse comprehension, show figurative language impairment, and have a selective difficulty with meaning suppression; they can activate word meanings, but are significantly impaired in suppressing contextually irrelevant meanings when compared to typically developing peers (Paul et al., 2003).

According to Huber-Okrainec et al. (2005), the transfer of language between the two cerebral hemispheres is being implicated in the corpus callosum. So, when children with SBM consisting of corpus callosum agenesis were asked to choose the appropriate picture with the corresponding idiom, it showed that they have difficulties with rejecting the literal interpretation of the idioms, and with accepting the figurative interpretation of all idioms, that they were slower to comprehend decomposable idioms albeit their understanding of these idioms was relatively well, and that they were poor in comprehending non-decomposable idioms. These difficulties seem to have a relation with the degree of degeneration of the corpus callosum, and especially the splenium. Huber-Okrainec et al. (2005) suggest that the corpus callosum is important for interhemispheric integration of idioms, and especially non-decomposable idioms, and that for rejecting contextually irrelevant literal meanings of ambiguous figurative idioms, an inhibitory role of the corpus callosum

is needed.

4.4 Unilateral brain damage

A study from Kempler et al. (1999) on individuals diagnosed with unilateral brain damage found that right-hemisphere damaged patients had more problems with idiomatic expressions than with literal ones, while left-hemisphere damaged patients displayed the opposite pattern, which, according to them, suggests that literal and idiomatic language is mediated by different brain structures, at least in adults. However, in children this dissociation is not found, which Kempler et al. (1999) explain by stating that the literal and figurative language functions can be sub-served by the undamaged areas of the brain in either the left hemisphere or the right hemisphere. Hemispheric lateralization, such as seen in adults, is not present in the children examined in their study, and therefore the dichotomy between literal and figurative language cannot be explained by lateralization. Unfortunately, Kempler et al. (1999) do not report specific brain areas implicated in their subjects.

5.0 Preliminary conclusion

Because of the number of overlapping brain regions between, on the one hand, idiom comprehension in subjects without brain damage and idiom comprehension in impaired subjects, and on the other hand AD/HD, such as the frontal regions, the (splenium of the) corpus callosum, the cerebellum and others (see Appendix I) one might wonder whether there could be indeed an idiom comprehension impairment present in AD/HD. We hypothesize that individuals with AD/HD have problems with idiom comprehension compared to controls. We will present individuals with AD/HD with three tasks: a picture-selecting task, a task where the correct definition of an idiom must be given and a task where an idiom must be matched with the correct story.

6.0 Methods

6.1 Subjects

Three participants aged 20-29 years old (mean age 24.3, SD 2.05) with a diagnosis of AD/HD were obtained (1 male, 2 females). The diagnosis was made during their childhood and not validated in this study; due to the limited resources available and not being qualified to test these individuals ourselves, it was not possible to conduct a psychological observation and interview the participant's parents. Individuals with a history of language problems or impairments, dyslexia or a form of autism were excluded, due to the fact that these disorders may interfere with the results obtained from the control group. They were matched with three controls on age (mean age of

controls 25.0, SD 2.16) and level of education. In total, we had six control subjects suited for this study; we selected the three best matching participants to be compared with the AD/HD-group. All participants gave informed consent to be part of this study.

6.2 Materials

At first, 30 randomly picked idioms from online journals published by *Genootschap Onze Taal* (n.d.), a Dutch language association, were chosen. A survey was conducted to 8 individuals without any known disorder, aged 24-28 (mean age 25.7, SD 1.39) and with high levels of education (minimal level was an higher vocational education, maximum level was a masters degree), in which they had to determine whether each of the 30 idioms were familiar or not, on a scale from 1 to 5 (1 being 'not familiar, nor ever used this idiom', 3 being 'not familiar, not unfamiliar', and 5 being 'familiar and used this idiom'). We decided that 3.5 out of 5 was the cut off for an idiom to be familiar instead of 2.5, because of high variability of idiom familiarity between individuals. This gave us a total of 17 idioms, from which we omitted the two idioms with the lowest familiarity score, ending with 15 idioms to use in our pilot study. For a full list of these 15 idioms and the familiarity rating per idiom, see Appendix II.

Idioms were both ambiguous and non-ambiguous, in order to test whether a possible failure in idiom comprehension in individuals with AD/HD was due to purely poor idiom comprehension or also due to difficulties with incorporating context and thus the ability to solve lexical ambiguities. In ambiguous idioms, it is also possible to have a literal meaning, while in non-ambiguous idioms, the literal meaning does not make sense. For instance, with an ambiguous idiom such as *een staartje krijgen* (lit: getting a tail, fig: it is not over yet), the possible literal interpretation might be of a girl getting a (pony)tail. The literal interpretation of a non-ambiguous idiom such as *de berg heeft een muis gebaard* (lit: the mountain gave birth to a mouse, fig: high expectations that were not met) does not, in reality, make much sense. We decided whether an idiom was ambiguous or not by determining if the literal interpretation of an idiom could in fact happen in real life, or whether this was absurd. In total, there were 8 non-ambiguous idioms and 7 ambiguous idioms. The 15 test items were randomly divided into groups of 5, however, we made sure that every group had at least 2 non-ambiguous idioms.

6.3 Tasks

In the first part of the survey, 5 test items were provided and participants had to choose between two pictures, one that showed the figurative meaning and one that showed the literal meaning (adopted from Papagno et al., 2003, see Appendix III for the pictures). This task will

reflect the comprehension of the concerning idioms; one does not have to produce the meaning of the idiom themselves, they simply have to choose the right corresponding picture, showing if idiom comprehension in its essence is disturbed.

In the second task, consisting of 2 ambiguous and 3 non-ambiguous items, the participants had to give a short definition of the idioms (see Appendix III), which requires a greater processing demand of the participant's language network; it appeals also to semantic retrieval and suppression of unrelated concepts.

In the third and last task, again consisting of 5 items, the participants had to choose between three short stories that corresponded, according to their judgment, with the meaning of the given idiom (see Appendix III). This might help us uncover whether the AD/HD-group have difficulties with incorporating context in the comprehension of idioms. For the scoring of the answers on each task, see Appendix IV.

7.0 Results

A MANOVA was chosen to analyze the results because we had one independent variable (diagnosis: AD/HD versus non-AD/HD) and multiple dependent variables (the answers to the questions of the survey), using a significance level of 0.05 ($p < 0.05$). The results show that, overall, no group effect was found (see Table 1). Only questions 5, 7, 8, 9 and 10 show significancy levels (0.374, 0.519, 0.158, 0.374, 0.374), however, these are far greater than the significancy level of 0.05. When looking at the results separated by task, there is no significance found either; the significance levels for each task looked at separately, are identical to the significancy levels found when all the tasks are analyzed as one test.

Source	Dependent variable	Type II Sum of Squares	df	Mean Square	F	Sig.
Diagnosis	q1	0.000	1	0.000	.	.
	q2	0.000	1	0.000	.	.
	q3	0.000	1	0.000	.	.
	q4	0.000	1	0.000	.	.
	q5	0.167	1	0.167	1.000	0.374
	q6	0.000	1	0.000	.	.
	q7	0.667	1	0.667	0.500	0.519
	q8	1.500	1	1.500	3.000	0.158
	q9	0.167	1	0.167	1.000	0.374
	q10	0.167	1	0.167	1.000	0.374
	q11	0.000	1	0.000	.	.
	q12	0.000	1	0.000	.	.
	q13	0.000	1	0.000	.	.

q14	0.000	1	0.000	.	.
q15	0.000	1	0.000	.	.

Table 1: results from a MANOVA-analysis, significance scores for independent variable diagnosis compared to dependent variables q1-q15.

8.0 Conclusion and discussion

While it is clear that brain regions implicated in AD/HD overlap with implicated brain regions in various disorders where poor idiom comprehension is one of the symptoms, the results of this pilot study show no evidence for poor idiom comprehension in AD/HD at all. However, the number of participants examined may have an effect on our results; only three participants with AD/HD were questioned, and a bigger study might be more fruitful. It is also possible that, as is with pragmatic problems in individuals with AD/HD (Camarata et al., 1999) the age group examined (20-29 years old) improved their comprehension of idioms as they aged; children with AD/HD seem to have more problems with pragmatic aspects of language than adolescents or young adults with AD/HD. Also, we cannot argue that no adult individuals with AD/HD have idiom comprehension problems; perhaps the participants in this study were too highly educated, or perhaps the three participants with AD/HD that were investigated simply do not have idiom comprehension problems. Another issue that could have influenced the results is the fact that the three tasks used in this study were too accessible; for example, choosing the right picture that corresponds with a given idiom might be difficult for Alzheimer's disease patients because of their degrading cognitive abilities, but it might be too easy for individuals with AD/HD, as they are largely of average intelligence (having an IQ score of approximately 100).

Even though this study shows no idiom comprehension difficulties in individuals with AD/HD, considering the fact that, however, there is a great deal of overlap in impaired brain regions in these individuals and in individuals with other disorders that do experience difficulties with idioms, it might be worthwhile to investigate this issue further and more extensive in the future. One of the treatments for AD/HD, next to stimulant medication, is therapy (Mar et al., 2010). Figurative language and idioms are important in everyday speech and thus may occur frequently during therapy sessions. If further research does show that there is indeed AD/HD a relationship with difficulties in comprehending idioms, it might lead to misunderstandings during therapy sessions, and thus could lead to less effective therapy. Also, it might lead to difficulties during social interactions, such as frequent misunderstandings, and, in an educational setting, it might pose problems whenever educators frequently use figurative language to explain subject matter.

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Appendix I

Brain regions implicated in idiom comprehension, figurative language in general, literal language in general, executive functioning, impaired idiom comprehension and AD/HD.

Normal functioning	**Brain regions**
Idioms	
Papagno et al. (2001)	Both right and left hemispheric regions
Kempler et al., (1999)	Right hemisphere
Oliveri et al., (2004)	Left hemisphere
Huber-Okrainec et al., (2005)	Interhemispheric transfer
Borhn et al., (2012)	Left inferior frontal gyrus towards dorsolateral prefrontal cortex
Zempleni et al., 2007	Bilateral inferior frontal gyri, bilateral middle temporal gyri, left middle and inferior temporal gyri, right inferior frontal gyrus, left cerebellum, left occipital lobe (cuneus, lingual gyrus), right inferior frontal gyrus, right insula, left basal ganglia, left cerebellum, left precentral gyrus, bilateral inferior frontal gyri, bilateral temporal gyri
Figurative language	
Borhn et al., (2012)	Left inferior frontal gyrus to anterior insular cortex, right inferior frontal gyrus to right superior temporal gyrus, temporal gyrus, left middle temporal gyrus, medial frontal gyrus, left inferior temporal gyrus, left amygdala
Bottini et al., (1994)	parietal cortex, precuneus, middle and inferior temporal gyri, temporal pole, prefrontal and basal frontal cortex of the left hemisphere, posterior cingulate, precuneus, middle temporal gyrus, prefrontal cortex of the right hemisphere
Literal language	
Borhn et al., (2012)	Medial bilateral precuneus/cuneus, right middle frontal gyrus, right inferior parietal lobe. Inferior frontal gyrus of the right hemisphere, frontotemporal lobes of the left hemisphere, inferior frontal gyrus
Bottini et al., (1994)	Frontotemporal lobes of the left hemisphere, inferior frontal gyrus, parietal cortex, precuneus, middle and inferior temporal gyri, temporal pole, prefrontral and basal frontal cortex of the left hemisphere
Executive functioning	
Papagno et al., (2003)	(dorsolateral) frontal lobe, prefrontal cortex especially dorsolateral

	prefrontal cortex
Interhemispheric transfer	
Sidtis et al., (1981)	Corpus callosum, especially the anterior part, the body and the splenium
Attention	
Mar et al., (2010)	Superior colliculus in the midbrain, pulvinar of the thalamus, posterior parietal cortex, middle dorsolateral prefrontal cortex
Impulsivity	
Mar et al., (2010)	Bilateral activation in inferior frontal cortex, anterior cingulate cortex, supplementary motor area, dorsolateral prefrontal cortex, inferior parietal cortex, lateral prefrontal and intraparietal cortical regions, ventral striatum, medial orbitofrontal cortex

Impaired functioning in relation to idiom comprehension	**Brain regions**
Alzheimer's disease	
Winner and Gardner, (1977)	Right hemisphere
Aphasia	
Papagno et al., (2003)	Left hemisphere
Cacciari et al., (2014)	Frontal subcortical area, cortical temporal region
Corpus callosum agenesis	
Huber-Okrainec et al., (2005)	Corpus callosum, especially the splenium
Unilateral brain damage	
Kempler et al., (1999)	Right hemisphere
General brain damage	
Papagno (2004)	Right hemisphere

Impaired in AD/HD	**Brain regions**
Berquin and Godefroy, (2010)	Cerebello-thalamo prefrontal circuit, basal ganglia, most notably the caudate nucleus, cerebellum, (mainly) right prefrontal cortex, splenium of the corpus callosum, no normal left-right asymmetry in the anterior brain and caudate nuclei, smaller globus pallidus, stratio-prefrontal circuit, anterior frontal region and striatum

Appendix II

Results of the preliminary investigation done to examine the familiarity of thirty idioms

Idioms	1	2	3	4	5	Standard deviation	Familiarity score from 1 to 5
Men moet zijn bed maken zoals men slapen wil.	7 (87.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	2.73	1.50
Ieder huisje heeft zijn kruisje.	1 (12.5%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	6 (75.0%)	2.24	4.38
Een staartje krijgen.	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (12.5%)	6 (75.0%)	2.24	4.50
Hij is in de aap gelogeerd.	2 (25.0%)	1 (12.5%)	0 (0.0%)	2 (25.0%)	3 (37.5%)	1.02	3.38
De berg heeft een muis gebaard.	7 (87.5%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2.73	1.13
Uit je hand laten eten	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	7 (87.5%)	2.73	4.88
Op je buik schrijven.	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (100.0%)	3.20	5.00
De dood of de gladiolen.	3 (37.5%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	4 (50.0%)	1.62	3.38
Met de Franse slag.	4 (50.0%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	3 (37.5%)	1.62	2.63
Van hak op de tak.	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (100.0%)	3.20	5.00
Van heinde en verre komen.	0 (0.0%)	0 (0.0%)	2 (25.0%)	0 (0.0%)	6 (75.0%)	2.33	4.50
In een ivoren toren zitten.	3 (37.5%)	0 (0.0%)	0 (0.0%)	2 (25.0%)	3 (37.5%)	1.36	3.25
De kat op het spek binden.	2 (25.0%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	5 (62.5%)	1.85	3.63
De kogel is door de kerk.	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	7 (87.5%)	2.73	4.88
Leven in de brouwerij.	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	7 (87.5%)	2.73	4.88
De loef afsteken.	2 (25.0%)	1 (12.5%)	0 (0.0%)	4 (50.0%)	1 (12.5%)	1.36	3.13
Oude koeien uit de sloot halen.	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (100.0%)	3.20	5.00

sloot halen.	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(100.0%)		
Pappen en	3	0	0	1	4	1.62	3.38
nathouden.	(37.5%)	(0.0%)	(0.0%)	(12.5%)	(50.0%)		
Op de pof.	4	0	0	2	2	1.50	2.75
	(50.0%)	(0.0%)	(0.0%)	(25.0%)	(25.0%)		
Een rib uit mijn lijf.	0	0	0	0	8	3.20	5.00
	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(100.0%)		
Schepen achter zich	0	1	1	2	4	1.36	4.13
verbranden.	(0.0%)	(12.5%)	(12.5%)	(25.0%)	(50.0%)		
Op stang jagen.	1	1	0	1	5	1.74	4.00
	(12.5%)	(12.5%)	(0.0%)	(12.5%)	(62.5%)		
Aan de strijkstok	2	1	1	2	2	0.49	3.13
hangen.	(25.0%)	(12.5%)	(12.5%)	(25.0%)	(25.0%)		
Op je tandvlees	1	1	0	1	5	1.74	4.00
lopen.	(12.5%)	(12.5%)	(0.0%)	(12.5%)	(62.5%)		
Een uiltje knappen.	0	0	0	0	8	3.20	5.00
	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(100.0%)		
Op de valreep.	0	0	0	0	8	3.20	5.00
	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(100.0%)		
Groene vingers	0	0	0	0	8	3.20	5.00
hebben	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(100.0%)		
Zoals de waard is,	1	3	1	1	2	0.80	3.00
vertrouwd hij zijn	(12.5%)	(37.5%)	(12.5%)	(12.5%)	(25.0%)		
gasten.							
Aan de wilgen	2	0	0	1	5	1.85	3.88
hangen.	(25.0%)	(0.0%)	(0.0%)	(12.5%)	(62.5%)		
In zak en as zitten.	2	0	0	0	6	2.33	4.00
	(25.0%)	(0.0%)	(0.0%)	(0.0%)	(75.0%)		
							3.85

1: completely unfamiliar

2: little bit unfamiliar

3: not unfamiliar, not familiar

4: little bit familiar

5: completely familiar

Appendix III

Questions asked in the survey used for this study.

Task 1: selecting the right picture corresponding to the given idiom

1: “Groene vingers hebben”

Picture 1:

Picture 2:

2: “Leven in de brouwerij”

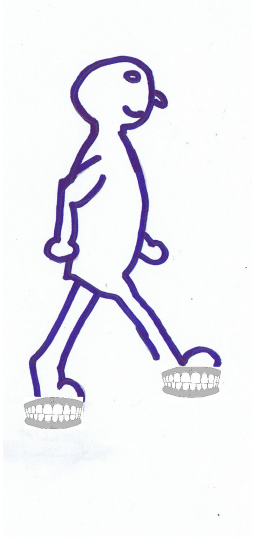
Picture 1:

Picture 2:

3: “Op je tandvlees lopen”

Picture 1:

Picture 2:



4: “Een uiltje knappen”

Picture 1:

Picture 2:

5: “Schepen achter zich verbranden”

Picture 1:

Picture 2:

(all images except for image 3.2 and image 4.1 are courtesy of Google)

Task 2: filling in the definition of the given idiom.

6: “In zak en as zitten”

7: “Uit je hand laten eten”

8: “Op stang jagen”

9: “Een rib uit mijn lijf”

10: “Iets aan de wilgen hangen”

Task 3: picking the right story corresponding to the given idiom.

11: “De kogel is door de kerk”

- Story 1: Het huwelijk is in volle gang. Opeens klinkt er een luide knal. Iedereen is verbaasd, niemand weet waar het geluid vandaan kwam. Maar dan ziet één van de gasten opeens een kogelgat in de hoed van de bruidegom, een sluipschutter! Gelukkig is er niemand gewond geraakt en gaat het huwelijk met veel rumoer verder. Lachend grappen de gasten later op de receptie "Nou, de kogel is door de kerk!"

- Story 2: Na urenlange vergaderingen, afspraken en overleg met zijn vrouw, weet Rob het nog steeds niet. Hij ligt 's nachts in bed te woelen en te tobben, wat zal hij doen? Uiteindelijk is het moment aangebroken waarop hij wel móét beslissen. Hij loopt het kantoor van zijn baas in en zegt "Ik neem de nieuwe baan, ik dien mijn ontslag in." "Eindelijk," antwoord zijn baas "de kogel is door de kerk."

12: “Van hak op de tak”

- Story 1: "Kijk die gekke vogel nou!" zegt mijn dochter opeens uit het niets. "Hij weet niet

op welke tak hij het lekkerst zit, hij springt de hele tijd van de hak op de tak!"

- Story 2: De lerares van groep twee heeft een heel druk jongetje in haar klas,Robbie. Wanneer het tijd is voor de ouderavonden en zijn ouders voor haar zitten, vertelt ze hen dat Robbie een ontzettend leuk en slim kind is, maar dat hij niet goed is in begrijpelijke gesprekken voeren. Ja, dat hadden zijn ouders ook al door, maar wat doe je er aan, sommige kinderen springen nou eenmaal van de hak op de tak.

13: “Een staartje krijgen”

- Story 1: De muis van mijn zusje bleek zwanger te zijn en vandaag was het zo ver; de jongen zijn geboren. Toen ik de schattige babymuisjes ging bekijken, viel me meteen op dat één ervan geen staart heeft. "Ach," zei mijn zusje, "dit muisje krijgt nog wel een staartje, soms duurt het even."

- Story 2: Twee van de kinderen uit de buurt zijn dol op kattenkwaad uithalen; belletje lellen, mensen voor de gek houden, stiekem huisnummers omwisselen. Wanneer een buurman ze op heterdaad betrapt terwijl ze met sneeuwballen met daarin een steen aan het gooien zijn, en deze bij iemand door de ruit heen vliegt, rennen de kinderen heel snel weg. "Ren maar!" roept de buurman, "Dit krijgt nog wel een staartje!"

14: “Op je buik schrijven”

- Story 1: Morgen is er een belangrijk tentamen, maar Marie en Sanne hebben nog helemaal niks gedaan. In paniek zijn ze samen de stof aan het doornemen, maar tevergeefs, het blijft niet hangen. Marie oppert om dan maar spiekbriefjes te maken, maar Sanne ziet dat niet zo zitten; ze is bang om gepakt te worden en een onvoldoende te halen voor het tentamen. Marie blijft aandringen en uiteindelijk gaat Sanne overstag. Marie zegt tegen Sanne: "Hier zijn de belangrijkste begrippen voor het tentamen, maar kijk uit, niemand mag zien dat je spiekt. Je kunt het op je buik schrijven."

- Story 2: Joris is uit met zijn vrienden. In het café waar ze momenteel rondhangen komt een groepje meisjes binnen, waarvan één van de meisjes meteen Joris zijn blik vangt. Wanneer hij genoeg moed heeft verzameld, besluit hij om op haar af te stappen. Hij biedt haar een drankje aan en vraagt "Heb je zin om zo met mij mee naar huis te gaan?" waarop het meisje

antwoord ""Dat kun je op je buik schrijven."

15: “Ieder huisje heeft zijn kruisje”

- Story 1: Maarten gaat voor het eerst naar het geboortedorp van zijn studievriend Alfred. De ouders van Alfred zijn een week op vakantie, dus ze maken met veel plezier gebruik van het ouderlijke huis. Terwijl ze vanaf de bushalte naar het huis lopen, valt het Maarten op dat er in elk raam een kruis hangt en vraagt aan Alfred waarom dit zo is. Alfred antwoord hierop dat hij opgegroeid is in een christelijk dorp, en dat in elk huisje zijn kruisje heeft.

- Story 2: Valerie en Manon hebben een gezellige meidenmiddag in de stad. Na een paar uur flink shoppen besluiten ze om een terrasje te pakken. Valerie vertelt aan Manon dat het tussen haar en haar vriend al een tijdje niet zo goed zit en dat ze zich even geen raad weet. Manon probeert haar goedbedoeld advies te geven, maar Valerie neemt hier weinig van aan; immers, Manon heeft een perfecte relatie, toch? "Nee," antwoord Manon, "Ik en Stijn hebben bijna elke dag ruzie." "Oh echt?" zegt Valerie, "Nou, zo zie je maar weer: ieder huisje heeft zijn kruisje."

Appendix IV

Example of how participant's answers on the survey were scored.

Diagnosis:

Dyslexia: 1

Some form of autism: 2

ADHD: 3

Language problems: 4

None of the above: 5

Sex:

Male: 1

Female: 2

Educational level:

Elementary school: 1

High school: 2

MBO: 3

HBO: 4

University: 5

Age groups:

15-19 years: 1

20-24 years: 2

25-29 years: 3

30 years or older: 4

Native speaker of Dutch:

Yes: 1

No: 2

Questions 1 to 5:

Good answer: 1

False answer: 2

Questions 6 to 10:

Target word given (such as 'stoppen' in “Iets aan de wilgen hangen”): 1

Word given that is semantically related to target word: 2

No target word given at all: 3

Questions 7 to 15:

Good answer: 1

False answer: 2