ADHD and the power of generalization

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Chapter 3

Biomedical bias in academic textbooks

When authors do not to mention the limitations of ADHD brain-anatomical studies

Based on:

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Abstract

Studies of brain size of those classified with ADHD appear to reveal smaller brains when compared to 'normal' children. Yet, what does this mean? Even with the use of rigorously screened subgroups, so-called 'refined phenotypes' and 'well-controls', these studies show only group differences between children with and without an ADHD classification. Hence, many with ADHD do not have smaller brains while many without ADHD have relatively small brains. This study discusses academic textbooks used at universities in the Netherlands and reveals that textbook authors often generalize and rarely inform future professionals about the limitations of brain-anatomical studies into ADHD.

Keywords: ADHD, stigma, medicalization, generalization, deficiency-narrative

Introduction

ADHD is one of 400+ disorders that are defined and described in the DSM-5, the latest edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association 2013). According to the DSM-5, a 'diagnosis' is possible if a child meets six out of nine criteria for hyperactivity/impulsivity such as 'often fidgets with or taps hands or feet', 'often leaves seat', and/or six out of nine criteria for inattention, including 'often loses things necessary for task or activities'. In addition, children have to meet additional criteria, such as exhibiting these behaviors before age 12 and for a duration of at least six months (American Psychiatric Association, 2013). Furthermore, the behaviors must interfere with social and academic functioning.

In the research agenda for the DSM-5, the authors clearly stated that 'the field of psychiatry has thus far failed to indicate a single neurobiological cause for any of the mental disorders' (Kupfer, First, & Regier, 2008, p. 33). After many years of expensive brain-studies, ADHD has proven to be no exception; 'No single risk factor explains ADHD. Both inherited and non-inherited factors contribute and their effects are inter-dependent' (Thapar, Cooper, Eyre and Langley 2013, p. 3). Despite several associated factors and despite the clear cultural underpinnings of what we perceive as (ab)normal behavior (Freedman & Honkasilta, 2017), the authors of the DSM-5 have decided to classify ADHD as a '*neuro*developmental disorder'.

Many scholars strengthen the image of ADHD as a discrete brain disorder with questionable claims. For example, Russel Barkley, in a 2.5 hour video addressing parents of children classified with ADHD, states that in those who have inherited the disorder (about 2/3 according to Barkley) several brain regions are slightly smaller (3-10%) and 'cause' the disorder. However, these differences are 'not enough to use brain imaging to diagnose this disorder' (Barkley, 2013, 56th minute). Barkley's explanation is peculiar: how could they have discovered these differences other than by brain imaging? The differences are in fact not too small as one might assume from Barkley's description, but rather too inconsistent as the effect size between brain size and behavior is small – denoting the overlap between the case and the control groups. Such 'lack of group-to-individual generalizability' (Fisher et al., 2018) is the real reason that 'no brain imaging technique (…) is of any value for diagnosis' as Barkley states in the same video.

In a similar vein, much is made from the largest ADHD case-control study to date by Hoogman et al. (Hoogman et al., 2017). The study indicated, on average, a small delayed growth in 5 subcortical brain areas, while one area also appeared to be slightly bigger in individuals diagnosed with ADHD. These mean differences disappeared in adulthood. However, far-reaching claims were made from the results of this study, such

as: 'the data from our highly powered analysis confirm that patients with ADHD do have altered brains and therefore that ADHD is a disorder of the brain. This message is clear for clinicians to convey to parents and patients' (Hoogman et al. 2017, 316). Their conclusion incited a storm of critique (Batstra, te Meerman, Conners, and Frances, 2017; Bejerot, Nilsonne and Humble, 2017; Dehue et al., 2017), and a petition to withdraw the study altogether was initiated by the blogsite Mad In America.

The study was not withdrawn nor were changes made to the conclusions, which were reported in many newspapers worldwide. Readers, and particularly laypersons, may have difficulty understanding the lack of group to individual generalizability. Many in the group of those classified with ADHD have a larger brain than average, and many in the control group have a smaller-than-average brain. Secondly, both case- and control-groups often use rigorously screened individuals, called 'refined-phenotypes' (Holmes et al., 2000) and extremely 'well controls' (Horga, Kaur and Peterson, 2014), who hardly represent their respective populations (for a discussion see also te Meerman, Batstra, Grietens and Frances (2017). Thirdly, brain maturation is a 'moving developmental target' (Hyman, 2010) as children develop at their own rate. Mean differences disappear because brain growth can catch up later in life (Hoogman et al., 2017; Shaw et al., 2007). Fourthly, a correlation between ADHD related behaviors and any (brain) measure does not necessarily imply causality. Neuroplasticity, or the fact that brain structure and function change as a result of interaction with the environment is a well-known phenomenon, seen in musicians for instance (Hyde et al., 2009; Münte, Altenmüller and Jäncke, 2002). On the downside, poverty (Noble et al., 2015) and maltreatment in children (Riem, Alink, Out, Van Ijzendoorn and Bakermans-Kranenburg, 2015) are negatively associated with brain size. Lastly, even if differences would ever be found on the individual level, these would not necessarily imply a disorder. If a particular brain-characteristic will be discovered for homosexuality, does this mean we should add it to the DSM again after it was removed in the DSM-III? (Dehue, 2014). Brain scans might help studying behavior, but it is ultimately human beings that decide which behaviors are considered (in)appropriate (Dehue et al., 2017; Altermark, 2013).

Journalists (Gonon, Konsman, Cohen, Boraud and Boutron, 2012) and researchers (Gonon, Bezard and Boraud, 2011) may have mutual benefits for simplifying and overstating findings. These benefits include standing out amidst the fierce competition for publications and readership amongst authors, scientific journals and newspapers? However, there is another, perhaps more daunting question: are academically trained healthcare professionals, researchers and journalists sufficiently aware of the complicated relation between individual and group?

This study analyses how authors of academic textbooks disseminate critical information about case-control studies into brain anatomy of those classified with ADHD. We aim to answer the following two questions relating to group-to-individual and sample-to-population generalizations: first: are group outcomes rightly presented as mere averages with little predictive value for individuals? And second, are students reading these textbooks presented with additional information regarding well-controls and refined phenotypes?

Method

Data Selection

The Netherlands has 18 public universities, ten of which have a wide academic orientation including medical and behavioral scientific bachelor's and master's programs. The latter are included in this study. The remaining universities are theological (4), (primarily) technical (2), and agricultural (1). (Source: Association of universities in the Netherlands http://www.vsnu.nl). Study guides of medical and behavioral science programs were searched for the following subjects: psychopathology, (biological, cognitive, clinical, biological) psychology, psychiatry, psychiatric disorders, diagnostics and behavioral problems. The glossaries of the prescribed textbooks were then searched for the keywords 'Attention Deficit Hyperactivity Disorder' or ADHD. If the keyword was found, we checked if the book contained a (sub)section, paragraph or chapter on ADHD. Forty-three books were selected for analysis. We searched for the most recent versions up to January 2016. With this approach called purposeful sampling (Coyne, 1997), we selected the most up-to-date academic textbooks used by universities to educate future healthcare professionals.

Analytic framework and coding

Every section on ADHD was scanned, converted into text with optical character recognition software (OCR) and imported to Atlas TI, an application for qualitative data analysis. Next, all claims relating to empirical research concerned with volumetric measures of brains of subjects with ADHD were classified into five categories:

1. A non-generalizing claim, containing 'hedged' positions on the generalizations

Hedging can be considered as the 'expression of tentativeness' (Hyland, 1996, p. 433). Although hedges can bring unwanted 'fuzziness' (Crompton, 1997, p. 272), in the case of group-to-individual generalizations we argue hedges are necessary to avoid logical errors. A 'classic' way to hedge a generalization is by using 'tend to' (Black, Mecsnober,

Thuss and Tommassen, 2015, p. 30), other possibilities are for instance 'to contribute' and 'to cause', the latter being more definite (Black et al., 2015). So-called 'vague quantifiers' (Bradburn and Miles, 1979), e.g. 'a number of, a minority, a few, several, often', etc. (Hamp-Lyons & Heasley, 2006, p. 65), are also considered as hedges. Research outcomes referred to as 'group findings' or 'means/averages' are seen as hedges as well. Other hedges we considered as relevant to generalizations are words used to express 'a component of tentativeness or possibility', for instance *may*, *argue*, *believe*, or *hypothesis*. Particularly words like hypothesis, or theory, express 'epistemic modality' (Varttala, 1999, p. 183) well in our view.

2. ***A generalizing claim, stating that all classified with ADHD share a certain anatomical feature without hedges to clarify this.***

A neuro-anatomical finding without a hedge, was classified as generalizing. An example of this is: 'several brain regions, including the prefrontal cortex, are smaller in children with ADHD than in children without the diagnosis' (Bukatko and Daehler, 2012, p. 300). Note that these claims might contain hedges that do not relate to the generalization but to something else such as the number of researchers that allegedly support the claim. For instance: 'All structural magnetic resonance imaging (MRI) studies that measured frontal regions reported reduced volume in PFC, and several studies reported volume reductions in the caudate nucleus of the basal ganglia, a structure with close connections to dorsolateral and ventrolateral PFC' (Willcutt, 2010, p. 397). This sentence is classified as generalizing, and the reference to 'all', versus 'several' studies is not considered in this decision as it does not refer to brain-anatomy.

3. ***An ambiguous claim, in case of uncertainty about the claim being a generalization, or uncertainty about the claim referring to anatomy.***

These aforementioned hedges and quantifiers served as 'sensitizing concepts', as it is 'probably impossible to form an exhaustive taxonomy of potential lexical hedging devices in English' (Varttala, 1999, p. 183). There are phrases in which no such words are used, yet the phrases still do not seem to be full out generalizations. For example: '*volume of the frontal, striatal, and temporal lobe region has been found to be directly related to inhibition*' (Wicks-Nelson, 2015, p. 232). 'Directly related' is considered ambiguous because it seems to describe a stronger relation than the mere statistical association it actually refers to. Other phrases that we considered to be ambiguous are for instance those that are clearly generalizing, yet the authors do not make explicit whether brain-anatomy, -physiology or -chemistry, is implied.

4. Disclaimers hedging the generalization.

Furthermore, we coded the presence of 'disclaimers'. We define such disclaimers as a passage in which the authors reflect on the heterogeneity of neuro-anatomical findings by, for instance, mentioning the overlap between the research groups or explaining that not every person with ADHD has smaller brain structures. The difference between a disclaimer and a non-generalizing claim is that in the latter, the generalization of the claim itself is hedged while a disclaimer reflects on several or all of the neuro-anatomical findings.

5. Disclaimers regarding refined phenotypes and super healthy controls.

Finally, we analyzed the sections addressing ADHD for the presence of other critical considerations regarding the exact value of the average scores: the use of refined phenotypes and super healthy controls. Any consideration regarding the selection of case- or control groups was coded. For both type of disclaimers mentioned under section 4/5 we have analyzed external chapters, if these were cross-referenced in the ADHD section.

Consolidation, analysis and reporting

The claims were selected and coded as (non-)generalizing or ambiguous by the first author, after which the second author coded the same claims. This resulted in an inter-rater reliability of 0.76 (Cohens Kappa). The disagreements about claims were then discussed until full agreement was reached and the criteria were clarified or extended when needed. Then, the third author coded the claims that resulted in a Cohens Kappa of .94. After a final discussion, consensus was reached about all the codes.

Next, the (co)occurrence of the coded claims with disclaimers, and references to other chapters with disclaimers was determined. On the basis of these (co)occurrences, we classified the sections on ADHD in 4 categories. These categories ranged from sections that did not discuss brain anatomy at all, to sections that also included additional disclaimers and to those that contained only generalizing claims on brain anatomy.

Results

In the 43 academic textbooks, a total of 94 claims on anatomy were identified. Of those, n=48 (51%) were classified as generalizing. Thirty-seven claims (39%) were classified as non-generalizing. Nine claims (10%) were classified as ambiguous. An additional nineteen disclaimers were found relating to anatomy. These disclaimers clarify if claims represent theories (n=9), relate to group level (n=3), do not apply to each individual

(n=3), refer to the differences not being "reliable" (n=1), or refer to brain size being a mere association (n=3).

Notably, if a single disclaimer can compensate for all generalizing claims. The most important information is therefore revealed when the co-occurrences of disclaimers and (non)generalizing claims are established on the level of book chapters/sections. Figure 1 gives an overview of the co-occurrence in our data.

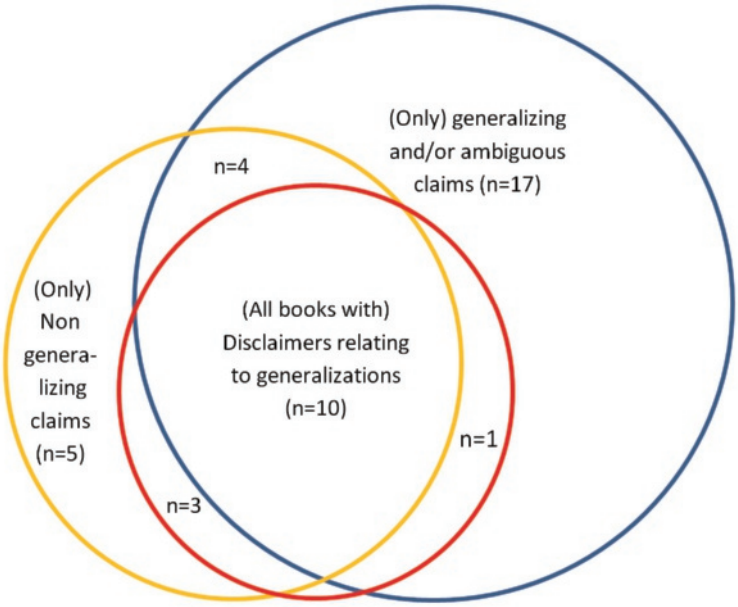

Figure 1. Books classified by presence/absence of claims/disclaimers

Chapters without disclaimers (n=21 (49%))

Because the co-occurrence statements and disclaimers is so important, we will discuss these co-occurrences on the level of chapters/sections, starting with sections that contain only generalizing/ambiguous statements without any disclaimer (n=17). In other instances (n=4) they co-occur with non-generalizing statements. We will exemplify some of the generalizing statements and elaborate on their differences and similarities, and the co-occurrence with non-generalizing or ambiguous claims. Table 1 displays how often the (non-) generalizing and ambiguous statements co-occur. Appendix A references the particular chapters of each category.

Table 1. Chapters containing generalizing/ambiguous claims without disclaimers

No disclaimers present n=21(49%)	Chapters	Generalizing claims	Disclaimers	Ambiguous claims	Non-generalizing claims	Phenotypes /controls
Only generalizing claims	n=12	✓	X	X	X	X
Generalizing and ambiguous claims	n=3	✓	X	✓	X	X
Generalizing and non-generalizing claims	n=3	✓	X	X	✓	X
Only ambiguous claims	n=2	X	X	✓	X	X
ambiguous and non-generalizing claims	n=1	X	X	✓	✓	X

X = not present in text

✓ = present in text

A chapter by Buitelaar and van der Gaag (2009) includes a generalization in its simplest form; without any disclaimers, non-generalizing or ambiguous claims present.

> *"Volumetric MRI-research with children and adults shows smaller volumes of grey matter (ibid, p.536)."*

The statement suggests that all children with an ADHD classification have smaller volumes of grey matter. Similarly, Kerig, Ludlow and Wenar (2012, p. 222) state:

> *"Magnetic resonance imaging (MRI) techniques have revealed that children with ADHD have a smaller splenium, which is the posterior portion of the corpus callosum (the structure connecting the two hemispheres of the brain)."*

In addition to the generalization, it is interesting to note that in these excerpts contain no reference and there is no mention of actual researchers who conducted the MRI study. Such a statement in which the original study and relevant information is stripped down so it becomes 'devoid of any trace of ownership, construction, time and place',

is called a 'positive modality' by Latour (1987). The phrasing suggests objectivity, as if the MRI-technology itself –has shown the anatomic differences. In the next paragraph, Kerig, Ludlow and Wenar add a statement that we classified as non-generalizing:

> *"It has even been suggested that the ADHD brain is wired differently (Konrad and Eickhoff, 2010). For example it has been proposed that ADHD may be dysfunction of or disconnection between brain regions that support the 'default network'."*

Because in this case the epistemological status is explicated, as it is 'suggested' that it 'may be a dysfunction (…) or disconnection', we classified this phrase as non-generalizing. However, the phrase does not place the earlier generalization about the splenium into perspective. Rather, it extrapolates that the brain might even be wired differently. The next example shows a similar generalization, although actual researchers and not MRI-scans are now the subject of the sentence. Barlow and Durand (2015) state:

> *"In general, researchers now know that the overall volume of the brain in those with this disorder is slightly smaller (3% to 4%) than in children without this disorder (…)."*

In this phrase the involvement of the 'researchers' seems to refer only to their 'knowing' the overall brain volume that is 3% to 4% smaller in children with ADHD: in general, researchers know of this alleged fact. The authors follow this statement with:

> *"A number of areas in the brains of those with ADHD appear affected, especially those involved in self-organizational abilities (…)."*

The epistemological status is somewhat dubious; certain areas 'appear affected'. Therefore, we classified this sentence as ambiguous. Note that the ambiguity does not seem to have the intention to cast doubt on the findings in any way. Rather, it leads logically into the next sentence with which the paragraph ends:

> *"These changes seem less pronounced in persons who received medication (...)."*

As the effects of medication are not the subject of this study, this sentence was not coded. However, this statement clearly reveals what Latour (1987, p. 23) explains as the purpose of positive modalities: they 'lead a statement away from its conditions of production, making it solid enough to render some consequences necessary'. In this case,

the merits of medication are now suggested; those who receive medication have less 'pronounced changes', less 'affected' brains. Carlson (2013, p. 601) generalizes research findings in a similar fashion, but depicts more agency on the part of the researchers:

> *A study by Shaw et al. (2007) found differences in the development of the brains of children with ADHD as well. The investigators found that cortical growth was delayed in children with ADHD.*

The author adds:

> *Ultimately, the growth of the brains of the children with ADHD caught up with those of unaffected children.*

Although this statement provides perspective about the relevance of brain size, it is still generalizing. This is problematic as it might obfuscate the fact that many children with an ADHD classification did not have 'slower developing brains' that needed 'catching up'. Mentioning group findings and discussing correlations seem to provide a way out of this conundrum. For instance, Higgins and George (2013, p. 247) state:

> *Both groups showed the usual pruning of the total gray matter as they grew through adolescence (Figure 20.8). However, two regions were unique when correlated with clinical outcome:*
> *1. Children who remained impaired at follow-up had thinner gray matter in the medial PFC at the beginning of the study.*
> *2. Children who grew out of the disorder showed a normalization of the gray matter thickness in the right parietal cortex.*

These statements show how the use of correlations and mentioning groups can avoid generalizations. Furthermore, it demonstrates how generalizing sentences can be nuanced by other non-generalizing sentences. The first two sentences are non-generalizing: *both groups showed the usual pruning*. And *two regions were unique when correlated*. The next two sentences (numbered 1 and 2) are generalizing in themselves, but they are rectified because the author addresses correlations. Four chapters in this category contained an ambiguous claim. In two cases it was unclear whether statements referred to neuro-anatomy or only to neurophysiology or chemistry. For instance, in van der Oord & ten Brink (2014, p. 295) it is stated:

> *Using uncomplicated language, the therapist explains the characteristics of ADHD to parents, comorbidity, the subtypes, potential genetic predisposition, the deficits in the brain (…).*

Possibly, the authors refer to neurochemical findings. This is not the focus of the current study, but it is important to mention as it is an even more varying characteristic than anatomy, with inconsistencies between studies and intra-personal differences from day to day (Weyandt, Swentosky and Gudmundsdottir, 2013). Therefore, this generalization is arguably even more poignant than those involving neuro-anatomy.

The following excerpt is considered ambiguous because, on the one hand, it generalizes while it also presents the results from MRI studies as mere indications. This is considered a hedge, although the generalization itself is not hedged.

> *Imaging studies (structural MRI) show indications that the total cerebral volume and the right cerebral volume in children with ADHD are significantly smaller than in normal children. (Slaats-Willemse 2011, p. 549).*

This sentence also exemplifies how the term significance can be used erroneously and/or confusingly. Significance depends on sample size and, in this case, difference between the averages of the case/control groups. The research and control sample can be significantly different in the statistical sense, but this does not mean that the differences in the population are *practically significant* (Daniel 1977). Nor does the research reveal meaningful information about individual children in the population, although the excerpt does suggest this. Unfortunately, in our data there were three out of seven statements that erroneously suggested significant results for individuals in the population.

Chapters with generalizing/ambiguous claims and non-generalizing claims in combination with hedges/disclaimers (n=10)

We will now discuss sections that contain disclaimers. Disclaimers occur alongside generalizing claims, in addition to already non-generalizing claims or, in some cases, in addition to both. We identified 10 ADHD sections in which all generalizations were hedged, or when extra caution was expressed by either a hedge or what we refer to as a 'disclaimer'. As we will demonstrate, the authors use disclaimers differently.

Table 2. Sections with generalizing/ambiguous claims and non-generalizing claims in combination with hedges/disclaimers (n=10).

Disclaimers present	Chapters	Generalizing claims	Disclaimers	Ambiguous claims	Non-generalizing claims	Pheno-types/ Controls
Generalizing claims, non-generalzing claims and disclaimers	n=4	✓	✓	X	✓	RF(n=1)
Non-generalizing claims and disclaimers	n=3	X	✓	X	✓	X
Generalizing claims and disclaimers	n=1	✓	✓	X	X	X
Generalizing claims, non- generalizing claims, ambiguous claims and disclaimers	n=1	✓	✓	✓	✓	X
Disclaimers, ambiguous claims and non-generalizing claims	n=1	X	✓	✓	✓	X

X = not present in text

✓ = present in text

RF: Refined Phenotypes discussed

One example of hedging is by starting a paragraph with a 'topic sentence' (van Loon, Thuss, Schmidt and Haines, 2013) that frames all subsequent generalizing claims in the paragraph. For instance, Sonuga-Barke and Taylor (2015, p. 744) start a section about ADHD and brain structure as follows:

> "*Structural alterations in multiple brain systems have been implicated in ADHD (Sonuga-Barke & Fairchild, 2012). Group comparisons with controls find significantly smaller brains in ADHD (Castellanos et al., 2002) with cerebellum, corpus callosum, striatal—for example, caudate nucleus, putamen and globus pallidus (Ellison-Wright et al., 2008) — and frontal regions—for example, dorso-lateral prefrontal cortex (DLPFC) (Valera et al, 2007) especially affected.*"

Although the first sentence is classified as generalizing, it introduces the topic, and in the next sentence the authors then discuss several case-control studies and indicate that those are 'group comparisons'. We have interpreted this sentence as a hedge, as the authors seem to have intended to indicate that all subsequent studies they mention in the paragraph are group comparisons. Carr (2016, p.376) uses a similar construction opening a paragraph about neuroimaging studies:

> *"Neuroimaging studies have shown that ADHD is associated with a range of structural and functional neuroanatomical abnormalities (…). The best established of these is lobar volume loss of around 3-4%, and abnormalities of the frontostriatal circuitry which underpins executive function."*

Because the authors mention that neuroimaging studies are 'associated' with abnormalities, we have classified this particular sentence as non-generalizing: association studies typically work with comparing averages, and hopefully, readers are able to view the results as relating to group differences only.

Disclaimer in (preliminary) conclusions/reflections/cross-reference.
An interesting disclaimer is found in Sonuga-Barke and Taylor (2015, p. 746).

> *"While it is helpful to think of ADHD as having a characteristic developmental phenotype that can be charted across the life span, the idea that there is a single trajectory runs counter to what we know of the complexity of ADHD developmental psychopathology (…) and the heterogeneity within disorders (see Chapter 3)."*

The excerpt does not entirely and unequivocally hedge the generalizations, but it does mention the heterogeneity of those classified with ADHD. Furthermore -using a cross-reference- this is the only section on ADHD that discusses sample-to-population issues by discussing the use of refined-phenotypes (Horga et al. 2014) in two famous studies by Shaw (2006; 2007) about ADHD and brain development.

> *"The ADHD participants were atypical in their high IQ, socially advantaged background and lack of comorbidities*
> *(Thapar et al. 2015, p. 33)."*

It is crucial information as it is likely that less explained variance from environmental factors is found in these youths from socially advantaged background.

The following disclaimers all relate to the fact that group outcomes cannot be generalized to individuals. For instance, Carr (2016, p. 376) ends a paragraph on anatomy with:

> *Not all cases of ADHD show all abnormalities. It is likely that the symptom patterns of different sub-groups of cases are associated with different neurophysiological abnormalities.*

The authors seem to have used this passage to avoid generalizations by referring to an 'association'. Furthermore, the authors explain that not all those with a diagnosis have 'abnormalities' in their brains. Unfortunately, the authors do seem to suggest that, at least *some* abnormalities are present, a claim that is not supported by existing scientific knowledge. Orobio de Castro, van der Oord, Raaijmakers and Prins (2009, p. 593) are more explicit in this respect:

> *Those who do a groupwise comparison of children with ADHD and children without ADHD, see differences (…) on brain scans and genetic make-up. However, it concerns different abnormalities in different children with ADHD, and there are consistently children with ADHD that do not differ from other children. It is not possible to diagnose ADHD in this fashion.*

In this statement, the authors provide a more thorough and less pathologizing disclaimer. First, they refer to *differences*, and not *abnormalities*. Second, they make clear that there are children diagnosed with ADHD 'that do not differ' from other children in terms of brain-anatomy. Wicks-Nelson (2015, p. 234) adds the following additional information:

> *The finding that non-diagnosed, typically developing youths exhibited brain changes similar to youths with the syndrome of ADHD lends neurobiological support to the dimensional view of ADHD.*

These authors do not refer to the 'case' group, but to the control group to make a similar point about the overlap between the groups: non-diagnosed children sometimes also have 'ADHD brains'.

These types of disclaimers are functional in the epistemological clarity they provide. We consider them examples of what Bruno Latour (1987) calls 'negative modalities', as opposed to 'positive modalities' discussed earlier. Negative modalities 'lead a statement (…) towards its conditions of production and (…) explain in detail why it is solid or weak'. Orobio de Castro et al. clearly add to this that due to heterogeneity it is not possible to diagnose ADHD with a brain scan.

In sum, each of the above disclaimers adds some additional perspective to the problem that group findings do not apply to individuals. Wilcutt (2010, p. 411), in Yeates, Ris, Taylor and Pennington (2010) mention the following in their conclusion:

> *"The neuropsychology of ADHD is clearly complex and multifactorial, with no single deficit that is necessary or sufficient to explain all cases of ADHD."*

This clear disclaimer nuances all previous generalizations by the author. Although factors associated with ADHD, such as brain size, do not necessarily 'explain' ADHD, it is a fine example of just how simple and effective such a disclaimer can be.

Chapters with only non-generalizing claims (n=5).

Several sections contain only non-generalizing claims. An example of this is Van der Oord and ten Brink (2014, p. 288), whose section mentions the group-level of the findings.

> *"MRI-research shows differences between groups with and without ADHD in three areas of the brain: the dorsolateral cortex, components of the basal ganglia and the cerebellum."*

Another example is Gazzaniga, Heatherton and Halpern (2016, p. 648), who state:

> *"Researchers have also demonstrated differences in the basal ganglia in the brains of some ADHD patients."*

The authors use the 'vague quantifier' (Schaeffer, 1991) *some* that gives a partial 'degree of certainty' (Hamp-Lyons and Heasley, 2006, p. 65). Such phrasing might be easier to interpret than Van der Oord and ten Brink's group findings, which still leave the option open that all people in the group show those differences. Gazzaniga et al.

do seem to suggest that the differences set some of the ADHD patients apart. The overlap in research groups, however, indicates that subjects in the control group could also have smaller brains. Comer (2014, p. 453) hedges the generalization by using the vague quantifier 'many'.

> *"Biological factors have been identified in many cases, particularly abnormal activity of the neurotransmitter dopamine and abnormalities in the frontal-striatal regions of the brain."*

It is dubious if 'many' is an appropriate term, as neuro-anatomical (as well as neurochemical) studies typically show only low effect sizes and abnormalities are not a necessary or sufficient condition for a classification. However, it is not a complete generalization. This fragment attests to the rigorous criteria we used to avoid 'overdiagnosing' textbooks as generalizing.

Chapters with no reference to anatomic brain studies and ADHD (n=7)

In this category we placed books that make no reference to case control studies relating to ADHD brain anatomy. In 6 cases, these sections were small (<3 pages). In one case an older book was used (1999), while many anatomic studies were conducted after 1999. One book (Tak, Bosch, Begeer and Albrecht, 2014) did have a relatively large section on ADHD (18 pages), yet with no reference to brain anatomic studies. A defiant, but defensible choice as anatomy is probably not the strongest associated factor in relation to ADHD. As these chapters do not contain information on ADHD in relation to anatomy, we do not discuss them further.

Discussion

Research question

Our research indicates that generalizations like 'patients with ADHD (…) have altered brains' of Hoogman and colleagues (2017) do not stand on their own. In academic textbooks used at universities in the Netherlands, group-to-individual generalizations seem like a bad habit that is the rule rather than the exception. Twenty-one out of 36 textbooks (58%) that discuss brain-anatomy have sections on ADHD with only generalizations and/or ambiguous claims that are not properly placed into perspective by disclaimers. Such generalizations conceal the limitations of what is known about ADHD and other DSM-constructs that lie 'upstream' (Latour, 1987, p. 22) when readers are invited to reflect on the inconsistencies. Generalizations obscure the pending questions

to take the readers 'downstream' to potential solutions. A vivid example from Durand and Barlow (2013, p. 517) has been discussed in the results. The authors first state that the "volume of the brain in those with this disorder is slightly smaller', but that the changes in the 'affected' brains are 'less pronounced in persons who received medication'. The sequence of these statements works to legitimize the use of psychostimulants as a cure. Ten textbooks (28%) did include a hedge or disclaimer. Only three of those properly discussed that a smaller brain is not a necessary or sufficient condition for an ADHD-classification. Only one author (Willcutt, 2010) mentioned both.

The problem of group-to-individual generalizations also seems to be related to an erroneous understanding of the term significance. Three authors suggest that *individual* children in the *population* have significantly smaller brains. Discussions about misunderstandings of significance repeatedly surfaced in relation to scientific education (for instance: (Hountras, 1957; Daniel, 1977; Cohen, 1990) which resulted in a guideline issued by The Task Force on Statistical Inference (Wilkinson, 1999). Despite this guideline, the emphasis on significance (Ware and Munafò, 2015) at the expense of sufficient conceptual understanding of effect size and overlap between research groups is still a problem (for a discussion see also Hoekstra, Finch, Kiers and Johnson, 2006).

None of the chapters placed the average findings of case-control studies in perspective, for instance by referring to the use of refined phenotypes or super healthy controls in those studies. Although four sections contained a cross-reference, only one of them, by Sonuga-Barke and Taylor (2015) in Thapar et al. (2015) cross-referenced a chapter that (implicitly) discussed refined phenotypes.

Relevance of the findings

The omnipresence of generalizations might indicate misinterpretations of case-control studies. However, in natural language, much is assumed or implicated. When a headline states that 'non-smokers live longer', many readers will know that this refers to an average. This phenomenon is known in discourse theory as 'implicature' (Renkema 2004). Grice's Maxims (Grice, Cole and Morgan, p. 1975) are famous in this respect, particularly his Maxim of quantity applies well: make information as informative as necessary, but no more than that. It might simply be superfluous to include that *on average* people who do not smoke live longer. For this reason, we have not considered standalone generalizations to be problematic per se. Hence, we considered generalizations in relation to non-generalizing statements, topic sentences, preliminary conclusions and disclaimers.

The question remains: superfluous to whom? Sperber and Wilson (1987) theorized that what is relevant or not, depends for a large part on the situation and community in which the discourse takes place, and discourse moves from one domain of discourse to another. Even if many beginning academics do realize these findings are mere averages, what happens when such information is transferred to a different discourse community, like parents of unruly children? For example, in our dataset van der Oord and ten Brink (2014) instruct counselors to explain 'the deficits in the brain' to parents of children classified with ADHD. When Hoogman et al. wrote a statement for the press about their research, they still did not hedge the generalizations of their study. And eventually, on the 16th of February 2017, the Dutch national news opened their 8 o'clock broadcast about this study with a video of a finger pointing at a brain scan and a voice-over saying 'ADHD can be seen on a brain scan' (Dutch Broadcast Foundation, 2017).

Strengths and Limitations

Considering the vague behavioral criteria –all containing for example the word 'often'- used for 'diagnosing' ADHD it should perhaps not be surprising that a very heterogeneous group of children is selected for research. Unfortunately, even the 'refined phenotypes' that are used cannot do much for homogeneity. For us, in a similar fashion 'diagnosing' chapters/sections in textbooks based on written text was a challenge, even if our criteria were clear and texts do not change from one moment to the next like behavior. It was difficult to do justice to all the idiosyncrasies we encountered in the way authors explain the ADHD-concept. For instance, the chapter on ADHD by Higgins and George (2013) does not have a disclaimer relating to generalizations, but several critical findings are discussed that we have not encountered in any other of the sections on ADHD. For example, the author mentions an –as of yet unpublished- study, presented at The American Academy of Neurology in 2011, that suggests the increasing risk for Parkinson's disease due to psychostimulants similar to those used in relation to ADHD (Van Den Eeden, 2011).

It must also be noted that discourse can be understood differently from one person to the next. Other designs with generalizing and non-generalizing texts given to experimental and control groups, followed by questionnaires or interviews can provide valuable additional information about how generalizations are perceived. Furthermore, we have analyzed segments about brain-anatomy in chapters/sections on ADHD and we have included only cross-referenced chapters as contextual information. It is also possible that other non-referenced chapters within those textbooks discuss the conceptual considerations we are critical of.

However, contextual information can also have a 'boosting' effect (Hyland, 1996) instead of giving proper perspective. For instance, similar generalizations as the ones we discuss occur regarding neurochemistry and neurophysiology (e.g. Kerig, Ludlow and Wenar, 2012, p. 221; Nolen-Hoeksema, 2014, p. 287). These can boost the suggestion that ADHD is a solid construct with clear physical attributes. Generalizations of neuro-physiology and –chemistry could be considered more serious as these findings are far less consistent than anatomic findings and may vary from day to day (Weyandt et al., 2013). Moreover, when ADHD is placed amidst physically measurable diseases such as Dementia, Alzheimer and Creutzfeldt-Jacobs such as is the case in Carter (2014), ADHD appears as a similar affliction.

Implications

Fortunately, scientific errors can be used effectively by teachers to explain the nature of science and its limitations (Allchin, 2012). Additionally, there are relatively straightforward ways to improve scientific writing in textbooks. For instance, with regard to the average findings in case-control studies that might not be a good representation of their populations, Sonuga-Barke and Taylor (2015) are two of the few authors who provide context that places findings into perspective. They do so by referring to a separate chapter in Rutter's Child and Adolescent Psychiatry (2015) with a cross-reference. This seems to be an efficient way as these conceptual issues regarding generalizability apply to all mental health conceptualizations. With a separate chapter the other sections can also cross reference to where there is sufficient space for thoughtful consideration of issues that warrant thoughtful reflection.

With regard to the applicability of group findings for individuals, the concept of 'necessary or sufficient' (Bailin, 2002) might be useful and simple enough to introduce in the separate sections on ADHD. Smaller brains are not necessary nor sufficient for a condition, period. A simple disclaimer that does not need to be applied to executive functions only, such as is the case in Danckaerts and Westermann (2014) who state: 'Although executive function deficits and aversion to delay are clearly associated with ADHD, both are neither necessary nor specific (sec) for the diagnosis'. Such a statement can easily be extended to expose the inconclusive findings relating to brain-anatomy, -chemistry, and -physiology alike and it is quite puzzling why the authors have not done so.

Textbooks used at universities literally provide off-the shelf knowledge to those who are likely to become the world's leading mental healthcare professionals. Reflecting more on science education could do much to instill thoughtfulness instead of gener-

alizing and pathologizing on average slower brain development and suggesting that potentially dangerous psychotropic drugs restore brain maturation.