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Bilingualism in autism

A meta-analysis

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Le bilinguisme dans l'autisme : une méta-analyse

RÉSUMÉ

La présente recherche est dédiée à une méta-analyse examinant les interactions entre le bilinguisme et le Trouble du Spectre Autistique (TSA). Son analyse se centralise sur les effets du bilinguisme dans les domaines cognitifs, adaptatifs, de communication sociale, et de linguistique des individus autistes. La méthodologie adoptée consiste en une revue systématique de la littérature suivie d'une méta-analyse. En incluant des populations diverses, cette approche a permis d'évaluer de manière exhaustive les bénéfices potentiels du bilinguisme ainsi que les effets de l'autisme sur ces quatre effets. Les résultats révèlent que le bilinguisme pourrait favoriser une résilience cognitive chez les personnes autistes. Cependant, les effets sur les fonctions adaptatives, la communication sociale et la linguistique montrent des valeurs d'effet moyennes à nulles, indiquant qu'il n'y a pas d'avantage ni de ralentissements spécifiques du bilinguisme. L'étude souligne également que les groupes monolingues autistes affichent des performances significativement inférieures par rapport aux groupes bilingues autistes et monolingues neurotypiques, spécifiquement dans les domaines cognitifs et linguistiques. Cette étude vise à mieux informer les personnes concernées sur le bilinguisme dans l'autisme ainsi qu'à promouvoir la sensibilisation sur ce sujet peu exploré dans la littérature.

MOTS-CLÉS

Autisme, bilinguisme, méta-analyse, TSA, cognitive, adaptive, social-communicative, linguistique

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List of abbreviations

Abbreviation	Definition
ASD	Autism Spectrum Disorder
ELS	Expressive Language Sampling
EF	Executive functioning
ToM	Theory of Mind
ASDB	ASD Bilinguals
ASDM	ASD Monolinguals
TDB	Typically developing bilinguals
TDM	Typically developing monolinguals
ASDBSEQ	Sequential bilingual with ASD
ASDBSIM	Simultaneous bilingual with ASD
ASDBH	High bilingual with ASD
ASDBL	Low bilingual with ASD

Glossary

Term	Description
Autism Spectrum Disorder	A complex neurodevelopmental condition characterized by persistent challenges in social interaction, communication, restricted or repetitive behaviours and the aptitude for cultivating, sustaining, and comprehending relationships (DSM-5, 2013, p. 31).
Bilingualism	The ability to speak two languages fluently
Early bilingual	Being exposed to a second language before the age of 7.
Late bilingual	Being exposed to a second language beyond the age of 7.
Simultaneous bilingual	Individual learning two languages simultaneously.
Sequential bilingual	An individual who acquires proficiency in a second language after already having established proficiency in their first language.
Bilingual home environment	A household where two languages are actively spoken.
Monolingual home environment	A household using only on language to communicate.
Cummins' *threshold hypothesis*	The recommendation to ensure that children achieve a basic level of proficiency in their first language before introducing them to a second.
Expressive Language Sampling	A language test collecting expressive language abilities during structured interactions with a clinician.
Random Assignment	Distinguishing tool between randomized control trials and quasi-experimental studies for detecting biases.
Independence of Assessors	Bias check on the familiarity between assessors and participants
Incomplete Outcome Data	Detection of bias tool concerning outcomes that were collected but not fully reported
Boundedness	Bias check on studies being either context-bound or of generalised change
Context-bound	Data collected in a familiar environment with known objects and people
Generalised change	Data collected using unfamiliar materials or examiners across diverse contexts
Distality	Detection of bias regarding whether the intervention effects were directly taught or occurred as developmentally downstream impacts
Proximity	Intervention collected within a small period of time

Introduction

The case of bilingualism in autism has been a topic of little discussion which has recently received more attention. The phenomenon of bilingualism involves the ability to use two languages fluently. While research on bilingualism has mainly focused on neurotypical populations, it is crucial to expand said research to diverse groups as well, particularly autistic individuals. Autism spectrum disorder[1] (ASD) is a developmental condition characterised by challenges in social interaction, communication, and restricted, repetitive behaviours. The interaction between bilingualism and autism presents a unique opportunity to explore how bilingualism may affect communicative, cognitive, linguistic, and social abilities in these populations.

Despite the increasing academic interest in bilingualism, its possible impact and relationship to autism remains poorly understood. This gap is even more significant given globalisation and the growing number of bilingual families, as well as the increase in autism diagnoses. Therefore, more studies on the matter need to be conducted in order to help fill these gaps and provide valuable information to those concerned.

Through these gaps certain questions arise: How does bilingualism affect the cognitive development of autistic individuals? What are the linguistic outcomes for autistic individuals raised in bilingual environments compared to those raised in monolingual environments? Does bilingualism offer an adaptive advantage to autistic individuals? How does bilingualism influence social communication skills in autistic individuals? How do autistic bilinguals compare to typically developing ones? Do they perform as well as autistic monolinguals? How about monolingual ASD individuals? How do they perform compared to neurotypical monolinguals?

[1] A considerable part of the autistic community doesn't agree with the term "disorder", as well as the use of the word "trouble" in the French version (TSA: Troubles du spectre de l'Autisme). I will, however, use the abbreviation "ASD" since no alternative term has been predominantly used in the literature so far. For more information on the best language to use regarding autism refer to: Geelhand, P., Papastamou, F., Belenger, M., Clin, E., Hickman, L., Keating, C. T., & Sowden, S. (2023). Autism-Related Language Preferences of French-Speaking Autistic Adults: An Online Survey.

An organised structure was put into place in order to provide comprehensive analysis on the matter. When exploring the complex interplay between autism and bilingualism, this thesis starts with an overview of both concepts, and delves into the challenges associated with bilingualism for individuals with autism. It later examines the potential drawbacks of enforcing monolingualism as well as some potential solutions and techniques that have been proven successful in the literature. Moreover, a section on methodology tackles the steps and tools used in order to conduct this study, such as search and coding strategies and the meta-analysis itself. The results section presents findings on detection bias and broader outcomes, leading to a comprehensive discussion of these results. The thesis concludes by exploring its limitations, suggesting future research, and finally summarising the significant insights gained throughout its process.

This thesis' subject matter was motivated by several reasons, both personal and professional. Growing up in a rural environment as well as a less developed country I experienced first-hand the lack of support and information that is available for handicapped individuals. I became close friends with a boy at school who was later diagnosed autistic. Despite not knowing it at the time I appreciated his unique way of thinking, something that the rest of the class considered "weird". This early interaction motivated me to volunteer in the inspiring project of the future autism centre of Brussels, "Maison de l'Autisme - Bruxelles", where I currently work fulltime. Although I am not certified to assist autistic individuals directly, I hope to make a meaningful contribution through this thesis and my professional endeavours.

1. Background

1.1. Autism Spectrum Disorder

ASD is the term universally used to characterise autistic individuals. The latter represents a complex neurodevelopmental condition characterized by persistent challenges in social interaction, communication, restricted or repetitive behaviours and the aptitude for cultivating, sustaining, and comprehending relationships (DSM-5, 2013, p. 31). The term "Spectrum" is employed to convey the distinctiveness of autistic individuals, who each may present diverse strengths, challenges, and characteristics, ranging from mild to severe. This is

epitomized by the common saying “If you've met one person with autism, you've met one person with autism” (Baker, 2013, p. 528), emphasizing the unique nature of each individual's experience within the spectrum.

The significant rise in ASD prevalence in recent years has raised significant concerns. A systematic review and meta-analysis on the prevalence of autism by Salari et al. (2022) concluded that the number of autism cases has mysteriously increased in recent decades. Factors such as changes in diagnostic criteria, heightened awareness, and methodological differences in studies contribute to the ambiguity surrounding ASD prevalence rates (DSM-5, 2013, p. 55). Salari et al. (2022, p. 4) present quantitative findings showing variations in the prevalence of ASD across continents, with rates of 0.4% in Asia, 1% in America, 0.5% in Europe, 1% in Africa, and 1.7% in Australia. Additionally, the male-to-female ratio in ASD populations is reported to be four times greater, as indicated in the DSM-5 (2013, p. 57). This notable increase observed in recent years highlights the need for further investigation in order to better understand the underlying factors contributing to this notable increase.

ASD can manifest in a complex array of effects across cognitive, adaptive functioning, social communication, and linguistic domains. While some individuals with ASD may exhibit remarkable cognitive abilities in specific areas, others may face challenges in executive functioning and theory of mind. Moreover, adaptive functioning varies widely, with some individuals demonstrating strengths in certain skills but struggle with daily life activities. Additionally, some prominent features of ASD involve social communication deficits as well as difficulties with interpreting social cues, while linguistic deficits can span from delayed language acquisition to non-verbal communication. Given the existing challenges that individuals with ASD already face, concerns that bilingualism will further complicate the already-present effects of autism arise.

1.2. Bilingualism

Bilingualism, the ability to speak two languages fluently, is a prevalent phenomenon observed in approximately half of the global population (Grosjean, 2010). The rise in bilingualism can be attributed to several factors, including increased globalisation, migration, and

multiculturalism. Many individuals choose to raise their children bilingually to preserve cultural heritage or gain competitive advantages in the workforce, thus preserving and increasing the number of bilinguals to this day. In a bilingual-dominated world, autistic individuals find themselves either deprived from or concerned with bilingualism. With the increasing prevalence of both bilingualism and ASD, exploring the relationship of these two phenomena can provide valuable insights into the impact of bilingualism on various outcomes in individuals with ASD who are bilingual.

While bilingualism may manifest in various forms, and types, the most important ones are influenced by environmental and age-related differences. There are two primary types of bilingualism based on the environment: individuals who are predominantly exposed to a second language through formal instruction, residing in bilingual cities or countries, or living in bilingual households. Conversely, there are those who are exposed to a second language at home without the intention of learning said language. Another noteworthy distinction is the age of acquisition. Some individuals are exposed to a second language before the age of 6, thus making them early bilinguals, while other may begin later on. A more comprehensive dive into the different types of bilingualism can be found in the Glossary (see Glossary). Depending on the type of bilingualism associated with an autistic individual, they may experience varying effects, highlighting the significance of this distinction in this study.

1.3. Bilingualism and autism

The exploration of bilingualism in ASD literature is relatively recent. Historically, there was a widespread misconception that introducing a second language to an autistic child could lead to confusion and language delays, as well as compromise intervention effectiveness and English acquisition (Yu, 2016, p. 1). However, such beliefs have not been substantiated in the literature, which indicate minimal to no negative impact of bilingualism on autistic individuals (Baker, 2013; Davis et al., 2022, 2023; Park, 2014). The sole potential concern, as described in Cummins' *threshold hypothesis* (1979, as cited by Baker, 2013), is the recommendation to ensure that children achieve a basic level of proficiency in their first language before introducing them to a second language. The latter suggesting that sequential bilinguals, particularly those with language disorders, may face difficulties in effectively

acquiring and utilizing a second language. Thankfully, the literature on the effects and possible benefits of bilingualism in autistic individuals is ever-growing, giving us a better understanding on the matter.

1.4. Parents' and Practitioner's Perception of Bilingualism in Autism

In addition to the increasing number of studies on bilingualism in ASD literature, researchers have begun to explore the perception and experiences of parents with autistic children who are concerned by bilingualism. There are different factors that may influence parents' decisions on whether to raise their autistic child bilingually or not. Some of them include cultural background, the country they are living in, influence by practitioners/clinicians and the availability of support.

With the markable raise of globalisation and specifically the number of families looking for a better future, parents have to prioritise the country's official language for their children's education. This concern resonates universally among parents, regardless of whether their children are neurotypical or not, so it is no surprise that parents raising autistic children may choose to focus on the educational language available in the country they moved into. As demonstrated by Yu (2013, p. 16), parents expressed the importance of their child learning English over their heritage language, emphasising that English would lead to better life opportunities as well as success in school. Another study however, illustrated through a survey, the same sentiment as a reason to raise a child bilingually (Kay-Raining Bird et al., 2012). On the one hand, parents expressed their motivation where "[t]he most frequently ranked reasons were the ability to communicate, living in a bilingual environment and the provision of life opportunities" (Kay-Raining Bird et al., 2012, p. 57). On the other hand, "[…] concerns regarding access to services or professional help and the ability of their child to learn two languages were ranked most frequently as important by these parents." (Kay-Raining Bird et al., 2012, p. 58). Given the complexity of the matter, when in doubt, most if not all parents will turn to the advice of practitioners/clinicians, including that of bilingualism.

The already existent worries on bilingualism are further heightened when professionals and clinicians advise against it, who themselves are mostly dubious about it (Kremer-Sadlik, 2005, Park, 2014, Seung et al., 2006, Srikar et al., 2022, Yu, 2009). This is especially true for non-native families seeking advice, who "[…] indicated that they were advised upon diagnosis of autism in their child to speak only one language to their child, namely English regardless of the parents' English proficiency" (Kremer-Sadlik, 2005, p. 1225). Kay-Raining Bird et al.'s survey further proves this dismissive view on bilingualism on a global scale regardless of the parents' heritage, where "most professional groups were more likely to advise the respondents to restrict input to a single language for their children with ASD." (2012, p. 58). Understandably, both parties are looking out for these children, mostly trying to avoid any possible confusion and/or struggle with their already impaired language. The only foundation of this sentiment against bilingualism that I could find in the literature was the already mentioned t*hreshold hypothesis* by Cummins (1979), which is also given as a possible influence by Kremer-Sadlik (2005, p. 1226). Srikar et al. (2022) better delves into the issue at hand:

> "Most professionals (family physicians, pediatricians, teachers, psychologists, and even speech-language pathologists) seemed to continue to recommend a monolingual approach […]. This is advised even for families that naturally speak two or more languages. […] Convincing other professionals to adopt a bi/multilingual approach can be quite challenging. This could be due to their lack of awareness of existing literature or their adherence to old practice (advice being handed down by clinicians over many years)" (p. 64)

A major challenge parents have to face is the evident lack of support and education for autistic bilinguals. As Srikar et al. explains (2022, p. 57), "[the] lack of speech-language therapy and special education services in their native language has increased parents' preference for English over their native language". Kay-Raining Bird et al.'s survey better emphasised parents' demands for more professional help, explaining how the lack of services

forces them to make decisions they do not agree with in the first place, such as their inability of choosing an immersion programme in their target language (2012, p.61). Firstly, Mueller et al.'s survey revealed the majority of professionals working with students with disabilities did not speak a second langue, with most supporting a monolingual approach (2006, p. 247). Secondly, Lim et al.'s systematic review on heritage languages in interventions captured a staggering 10% of autistic children receiving formal education in their native language (2019, p. 907). Both studies highlight the lack of specialised professional help that is available for those who choose to take a bilingual path/keep their native language.

In conclusion, the vague and debated discussion on bilingualism in autism brings numerous challenges and doubts for parents and professionals alike. Most professional advice often leans towards monolingualism, largely due to concerns that multilingual exposure may worsen communication and create confusion for autistic children. This advice persists regardless of the cultural needs and the negative experiences recorded by families that adopted such measures. In addition to professional abstention from bilingualism, parental decisions remain largely influenced by the lack of support and resources for bilingual autistic children. Addressing these challenges requires a shift in professional perspectives and the increase of guidance and information on the matter. Most importantly, additional research is essential in order to better understand bilingualism's potential for autistic individuals and when to advice for or against it.

1.5. The Dangers of Forced Monolingualism

It is no wonder that with all these concerns and constraints, parents raise their autistic children monolingually, most without knowing the possible consequences this might lead to. The consequences of forced monolingualism may vary depending on the parents' proficiency of the language chosen. Non-native families that move to say, an English-speaking country, and who are asked to speak only English to their autistic child, will struggle, especially if their English proficiency is limited. Such consequences have been thoroughly explored in the literature, such as issues with emotional connection and communication breakdown as well as limited parent input which involves all families regardless of L1 proficiency.

When parents are asked to stop using their native language to their children, a risk of emotional distance as well as communication breakdown is almost inevitable. The inability of parents to communicate with their children in their native language damages emotional connection and may jeopardise language development and social growth, particularly in autistic children, who will feel left out and less attached to their parents (Park, 2014, p. 125). The same has been reported for adolescents "[…] who talked to their parents in English rather than [their] mother tongue felt more emotionally distant and were less likely to engage in conversation with their parents" (Tseng & Fuligni, 2000, as cited by Kremer-Sadlik, 2005, p. 1227). Kremer-Sadlik further explored parents' experiences who admitted using their native language at home and with their neurotypical children except their autistic child (2005, p. 1232). Furthermore, she observed that during dinnertime, while the family conversed in their native tongue, the autistic child did not participate and righteously felt left out. The latter example correlates to Filmore's research that demonstrated how these children no longer understand what their parents say and the overall communication at home becomes fragmented (1991, as cited by Kremer-Sadlik, 2005, p. 1227). Finally, Kremer-Sadlik does not miss the absolute importance parents have in teaching their children social cues and speech acts as well as the importance of maintaining their heritage language:

> "Parents of autistic children are their primary source for language input, imitation, and practice, whether the children actively engage in activities with the parents, or simply overhear parents' social interactions.
>
> To be or not to be bilingual is NOT the question. These HFA children are brought up in a multilingual, multicultural society and in order to help them, in spite of their disorder, to become members of their community they have to be given the opportunity to learn both their mother tongue and English." (2005, p. 1232).

In conclusion, the decision to raise autistic children monolingually often results from concerns and constraints faced by parents, many of whom are unaware of the potential

negative consequences this decision may bring. These consequences are particularly pronounced for non-native families who must educate and raise their children in a language they do not master, nor do they feel attached to. Forced monolingualism can lead to emotional disconnection, communication breakdowns, as well as social and language development deficits for these autistic children. The importance of maintaining native language use within the family to preserve a healthy family structure is highlighted in current literature. Therefore, it is crucial for professionals and clinicians to avoid discouraging bilingualism immediately and instead, better inform parents, allowing families to make well-informed decisions while being aware of the possible negative outcomes.

1.6. Possible solutions and parents as trainers

Given the various concerns surrounding bilingualism and ASD, as well as the existing consequences of discouraging it, it is imperative to consider effective solutions. Several studies have tried to provide information on different points of interest when tempting to improve the situation on the matter. On the one hand, parental, clinical, and educational training are some of the areas that can be improved. While on the other hand, the undeniable role of parents is discussed alongside the effectiveness of "parent as trainers".

Several of the issues discussed previously, specifically on the lack of support and practitioner advice against bilingualism, can be linked to corresponding solutions. Kay-Raining Bird et al. give three important needs for parents with autistic children concerned by bilingualism (2012, p. 62):

a. The first suggestion given is on the importance of research on this topic. Such research can not only help inform parents, but also guide professionals in their perception of bilingualism and when to or whether to advice against it.
b. An important issue that unmistakably needs to be addressed is the lack of support. No matter the language or languages chosen by parents and autistic individuals, they all have a right to appropriate support. This need is heightened for multilingual countries where several languages are necessary for everyday life activities.

c. A third and final suggestion discussed is the need to train professionals on the matter, given the conflicting advice parents receive when looking for guidance.

Interestingly, Beauchamp & MacLeod, discussed the same issues alongside some more detailed suggestions on how to confront them (2017, p. 258). When addressing the lack of support as well as professional recommendations, they highlight how someone's minority language implies access to their minority culture. They later cite ASHA's document entitled *Issues in Ethics: Cultural and Linguistic Competence*: "Competent care is providing service that is respectful of, and responsive to, an individual's values, preferences, and language" (ASHA, 2013, Practice/ethics/Cultural-and-Linguistic-Competence/#sec1.6, as cited by Beauchamp & MacLeod, 2017). As an answer to these issues, they emphasize the importance of professionals not only being informed but also being obligated to do so in order to support minority language clients and their families.

Davis et al. (2021), in their analysis on the access to bilingualism for autistic individuals, take a different approach, focusing on three areas of interest: parental, clinical and educational. When discussing family-related issues, they emphasise on parents' tendency to easily fall victim to misinformation regarding bilingualism, leading to an unstable home environment for their children. Furthermore, clinicians are shown in the literature to fail to use tools associated to bilingual diagnosis not only for autistic individuals but also those with other developmental disorders. Finally, they showcase the lack of confidence in autistic students in the educational sector, resulting in an unfortunate exclusion of autistic students from bilingual education programs. In order to combat these barriers, several information and solutions are discussed.

In addressing the intersection of autism and bilingualism within families, potential solutions emerge from providing comprehensive information to parents affected as well as develop a better understanding not only on the effects of bilingualism, but other broader influences as well. Parents' understanding of autism is critical without a doubt, but when said parents come from a bilingual background/environment, the need for understanding bilingualism becomes even more important. As discussed in Kay-Raining Bird et al.'s first area of interest (2012), more research and information on this topic needs to be added in the literature. Ideally,

academic institutions as well as autism research centres need to raise awareness about bilingualism in autism in order to gather helpful and detailed information for parents as well as clinicians. Said research has to not only focus on "cognitive effects of bilingualism, but also on familial bonds, identity, community, and social inclusion." (Davis et al., 2021, p. 3).

When faced with uncertainty, parents typically turn to clinical support as their primary source of assistance which may lack accurate information and fail to utilise available resources. The latter can result in detrimental decisions with lasting consequences, further underlining the important role of clinical support. Davis et al. (2021) discusses similar suggestions to those of Kay-Raining Bird et al. (2012), regarding need for research providing up-to-date information and helpful tools for professionals. Davis et al. suggests institutions provide, when training clinicians, diversity and bilingual training, as well as help put in place checklists. Harris et al. (2014, as cited by Davis et al. 2021, p. 4) "designed a checklist for four of the most common autism screening tools used with culturally and linguistically diverse children". This checklist in not the only tool available to professionals, as demonstrated by Beauchamp & MacLeod, (2017, p. 258):

> "For professionals assessing bilingual children, it is important that testing be completed in the child's dominant language whenever possible. Dominance can be determined using a parent questionnaire such as the Alberta Language Environment Questionnaire (ALEQ; Paradis, 2011), the Gutiérrez-Clellen & Kreiter (2003) questionnaire or the Montreal Bilingual Language Use and Exposure Questionnaire (M-BLUE; Beauchamp & MacLeod)."

It is clear that not only are some clinicians lacking information, but they also appear to not be using the information and tools available to them.

The undying importance of school life and learning achieved in a classroom makes educator involvement a crucial participant in the development of autistic bilingual students. Most

schools, especially those with monolingual educators, do not offer bilingual programs, and a second language will depend on the interest of the class and availability of professors. The situation becomes ever more complicated for autistic students: "[In] a recent interview study with UK-based educators supporting autistic bilingual children (Howard et al., 2021) showed that although educators hold positive views about bilingualism, opinions vary greatly when it comes to autistic pupils" (Davis et al., 2021, p.4). Similarly to the suggestions given to clinicians, Davis et al. highlight the importance of informing and training educators working with autistic students who lack bilingual options in school. Although the literature on the effectiveness of bilingual programs in school is lacking, "[…] there are anecdotal accounts of successful programs introducing foreign languages into classrooms with autistic students (Lumsden and Ruchill Autism Unit, 2009, as cited by Davis et al., 2021, p. 4). In the hopes of improvement and change in the educational sector, parents must recognise their overarching role as the primary educators in their child's personal life.

When conventional sources such as general information, clinical support and educational programs fail to match the needs of parents with bilingual autistic children, the responsibility falls upon parents to take the most suitable course of action for their children's well-being. Kremer-Sadlik (2005), discussed in depth the idea of *parents as trainers* explaining how "[they] function as informal trainers teaching their children to attend to and recognize socio-cultural beliefs, norms, and expectations, as well as to be tuned to interlocutors' affective stances and other cues revealing their intentions, motivations, beliefs, desires, and knowledge" (p. 1228). Parents' undying role become even more heightened when it comes to autistic children. As cited by Kremer-Sadlik (2005), a study on language influence of autistic individuals by Baron-Cohen and Staunton (1994) found autistic children tend to adopt accents closer to those of their non-English-speaking mothers rather than their peers. Given their crucial role, upon discovering their child's autism diagnosis, parents deserve to have all the necessary information about autism as well as tools to help them make informed decisions for their child. A step ahead would be to teach parents home-based parent-implemented procedures that may normally be done by clinicians. Such initiative was examined by Soriano et al. (2021), who gathered data on the feasibility of home-based parent training procedures for English- and Spanish-speaking autistic children and adolescents. Unsurprisingly, most

parents learned to properly employ the language tests (Expressive Language Sampling - ELS) taught to them and effectively use them in their native language. Soriano et al. (2021, p. 12) concludes noting that this initiative marks the first implementation parent training from home, thus emphasising the necessity for further research in this field, given its success.

1.7. Bilingual Outcomes

Bilingualism requires the capacity of managing two languages independently which on its own is a remarkable skill. In addition, bilingualism can influence various developmental outcomes. This thesis delves into four critical domains where bilingualism may interfere: Cognitive, Adaptive Functioning, Social-Communication, and Linguistic outcomes. Each of these areas represents a fundamental skill of daily functioning and overall development. While research on neurotypical bilinguals appears promising, autism has mostly been overlooked. This section will present each outcome and explain what tasks involve around them. By investigating these domains, this study aims to provide a better understanding of each outcome in order to later investigate the possible effects that bilingualism may have on them for ASD individuals.

1.7.1. Cognitive

Cognitive skills are related with an important range of every-day skills such as learning, memory, paying attention, doing math, thinking and many more. The impact of bilingualism in cognitive tasks has been a big point of interest in the literature especially between neurotypical bilinguals and monolinguals, mostly suggesting a bilingual advantage. As Gunnerud et al. puts it: “The main theory that explains this presumed bilingual advantage asserts that learning two or more languages exercises the brain, which thereby enhances the bilingual individual’s performance in nonverbal cognitive tasks, such as planning, attention, working memory, and task switching” (2020, p. 1059). There has been research on the cognitive abilities of monolingual autistic individuals but mainly focusing on comparing them to neurotypical groups. A term often encountered in cognitive science is that of executive functioning (EF) that is linked to the cognitive domain. EF has received more interest in ASD

research given "the theory [that] executive dysfunction in autism […] [is] an explanatory account of the condition" (Gonzalez-Barrero & Nadig, 2019, p. 2). Another important term predominantly used when researching cognitive abilities is Theory of Mind (ToM). ToM is an additional important subject in autism research since it is a skill which autistic individuals often struggle with. It refers to the ability to interpret and/or predict other people's behaviour, emotions, and beliefs.

1.7.2. Adaptive Functioning

Adaptive functioning focuses on the practical skills needed for daily life, such as personal independence skills and responsiveness to changes in routine. "Research has found that children with ASD tend to have significant challenges with adaptive skill development compared to their typically developing peers" (Galicia, 2021, citing Carter et al., 1996). For individuals with ASD, challenges in adaptive behaviour can significantly impact their ability to function independently. In addition to these behaviours, skills such as socialising and expressive language may be found in the adaptive functioning category as well. In the case of bilingualism however, there is little to no research on whether bilingual exposure may enhance adaptive skills.

1.7.3. Social-Communication

Social-communication is a core deficit often encountered in ASD (DSM, 2013). Individuals with ASD frequently experience difficulties with verbal and non-verbal communication, understanding social cues, and maintaining conversations, which can challenge their ability to form relationships effectively. In exploring the interplay of bilingualism and ASD, recent research by Digard et al. (2022, p. 330), suggests that bilingualism might offer unique benefits to autistic individuals. According to their report, autistic bilinguals themselves have noted that being bilingual allowed them to engage more broadly with the world, opening up access to a diverse range of social opportunities and hobbies. These opportunities, in turn, have the potential to enhance their social communication skills. Such observations need to be addressed and put into question because if there is a bilingual advantage in social-

communication skills, bilingualism could be used as an intervention or at least be more favourable during professional counselling.

1.7.4. Linguistic

Lastly, the Linguistic domain assesses the effects of bilingualism on language acquisition and usage. The linguistic domain refers to the capabilities and performance in language use, including phonetics, vocabulary, syntax, pragmatics and so on. For individuals with ASD, language development can vary significantly, often characterised by delayed speech, echolalia, atypical use of language in social contexts and with some even being non-verbal. Traditional advice expresses concerns regarding bilingualism and language development, its main concerns being the possibility of confusion and inability to master two language registers. However, Baker (2013, p. 530) notes that while bilingual children may exhibit smaller vocabularies in each of their languages compared to monolingual children, they often possess a deeper or more nuanced linguistic understanding. Given the complexity of the matter, more research on linguistic abilities on both monolingual and bilingual ASD individuals needs to be added to the literature.

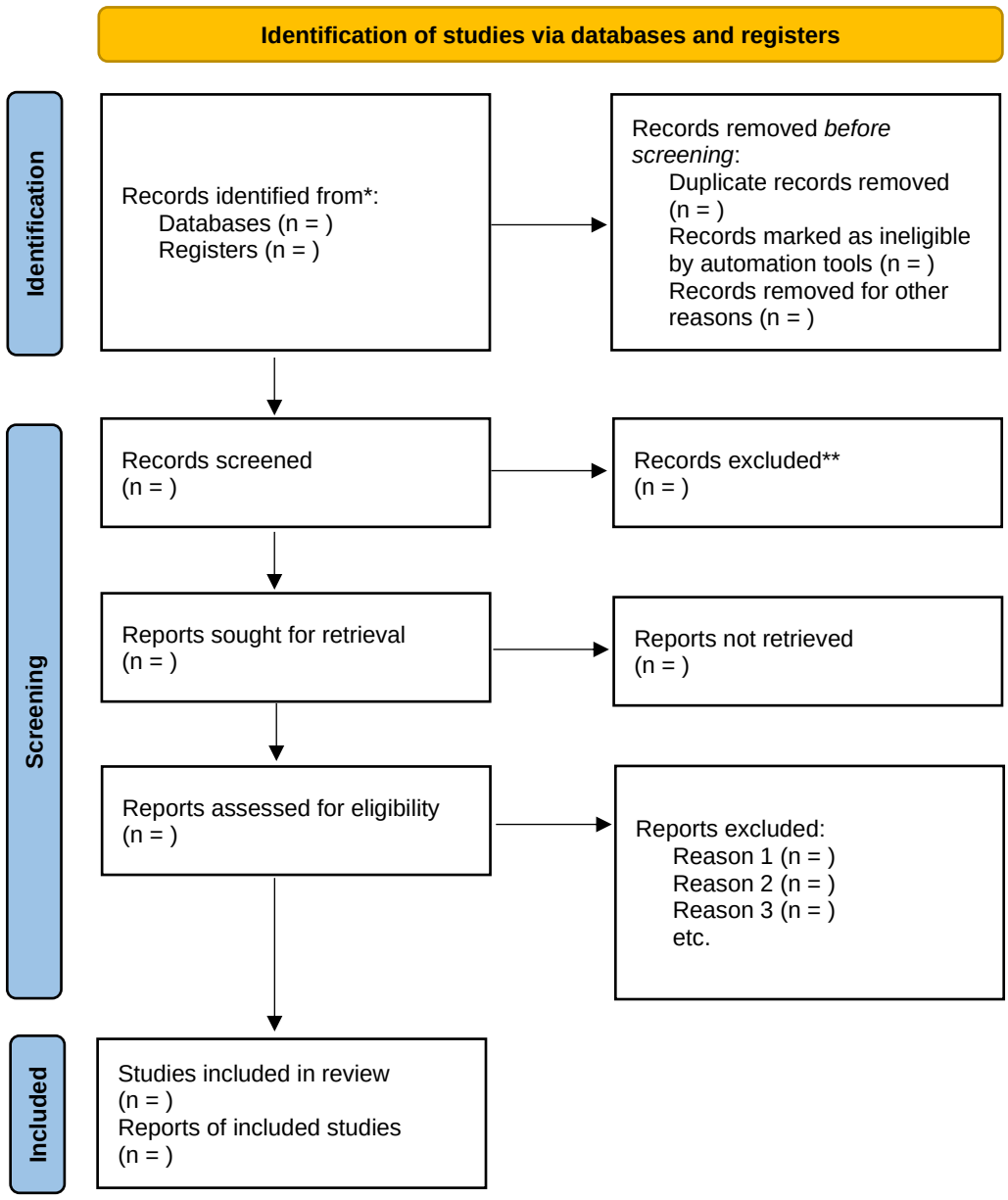
2. Methodology

2.1. Systematic Review and PRISMA

This study used a systematic review in order to research and gather studies that are correlated to the research question. As defined by Uman (2011, p. 57): “Systematic reviews, as the name implies, typically involve a detailed and comprehensive plan and search strategy derived a priori, with the goal of reducing bias by identifying, appraising, and synthesizing all relevant studies on a particular topic.”. Choosing a systematic review fits perfectly with this study since it will allow a comprehensive, extensive as well as objective overview on the effects of bilingualism in autistic individuals.

To enhance the organization of this systematic review, the study will employ the PRISMA method to address its research questions. PRISMA represents a basic collection of factual components employed for systematic reviews and meta-analyses reporting. It encompasses a 27-item checklist for inclusion in the report alongside a four-phase flow diagram. An empty spreadsheet (Page et al., 2021) is provided bellow in Figure 1 and will later be shown filled in the results section.

Figure 1 *PRISMA 2020 flow diagram empty*



2.2. Search Terms and Databases

2.2.1. Search Terms

The very first step of a systematic review is to dissect the issue at hand as well as identify its core concepts. The importance of the search terms used in such research is one of, if not the most important step, since any mistakes will lead to improper or lacking results. In order to identify the core concepts of my research question, I first looked into my research question:

"*Does bilingualism provide benefits for individuals with autism?*"

The purpose of this study is to examine the possible benefits of bilingualism in autistic individuals. Therefore, two main concepts can be extracted from such subject: autism and bilingualism.

Table 1 *Search Terms*

Concept Number	Concept Name	Search Terms
1	Autism	*Autism Spectrum Disorder, Asperger Syndrome, Autistic Disorder, Autism, Autistic and ASD*
2	Bilingualism	*Multilingualism, Bilingual, Bilingual Education, Second Language, language second, L2, Code-Switching, Interlanguage, Language Acquisition, Dual language, Two languages*

The first and main concept of my research question is without surprise, autism. Several terms were used that helped identify all studies that included autism in their research as shown in Table 1. The second concept that needed to be included was bilingualism. Bilingualism can be identified with different terms and such terms were used (see Table 1) in order to scan for studies within several databases.

2.2.2. Databases

The articles used for this thesis were gathered from various databases in order to maximise the number of results. The following databases were used in this systematic review: EBSCO, ERIC, Ovid MEDLINE, ProQuest, PubMed and Scopus Preview. ERIC was separated in two individual searches, one of peer-reviewed articles and grey literature. Supplementary to ERIC's grey literature, ProQuest also provided studies that were not peer-reviewed. All searches were conducted from July 2023 up to January 2024. When possible, automatic emails were sent matched to the search query in order to be aware of any new releases during the systematic review process. Individual searches were conducted in each of the databases above using the following terms (taken from Table 1): autism, autistic disorder, autism spectrum disorder, Asperger syndrome, autistic, ASD, multilingualism, bilingual, bilingual education, second language, language second, L2, code-switching, interlanguage, language acquisition, dual language, two languages. Additionally, a manual search was conducted using the query "bilingualism effects in autism" which provided 2 additional studies. A total of 5,273 articles were gathered throughout the whole search procedure.

2.2.3. Search Queries used in each Database

Each database has its own query language and may utilise MeSH terms, such as PubMed and ProQuest. Therefore, the concepts used although the same, had to be adapted to each database. Moreover, this study chose, as a chronological starting point, the year 1990, grounding itself in relatively recent literature. The table below offers a comprehensive breakdown of the different queries used in each database and the total of results obtained with and without duplicates (Table 2).

Table 2 *Search Queries used and total of results obtained*

N°	Database	Query used	Total number of results	Number without duplicates
1	EBSCO	*autistic Disorder or autism spectrum disorder or asperger syndrome or autism or autistic or asd* *AND* *multilingualism or bilingual or second language or L2 or code switching or code-switching or interlanguage bilingual education dual language or two languages*	**2011**	**1759**
2	ERIC	*("autistic disorder" OR "autism spectrum disorder" OR "asperger syndrome" OR "autism" OR "autistic" OR "asd") AND ("multilingualism" OR "bilingual" OR "second language" OR "L2" OR "code switching" OR "code-switching" OR "interlanguage" OR "bilingual education" OR "dual language" OR "two languages")*	**149**	**145**
3	ERIC GREY	("autistic disorder" OR "autism spectrum disorder" OR "asperger syndrome" OR "autism" OR "autistic" OR "asd") AND ("multilingualism" OR "bilingual" OR "second language" OR "L2" OR "code switching" OR "code-switching" OR "interlanguage" OR "bilingual education" OR "dual language" OR "two languages")	**62**	**59**
4	Ovid MEDLINE	*("autistic disorder" or "autism spectrum disorder" or "asperger syndrome" or "autism" or "autistic" or "asd").ab,ti. and ("multilingualism" or "bilingual" or "second language" or "L2" or "code switching" or "code-switching" or "interlanguage" or "bilingual education" or "dual language" or "two languages").ab,ti.*	**271**	**249**
5	ProQuest	*MJMESH.EXACT("Autism Spectrum Disorder") OR MJMESH.EXACT("Autistic Disorder") OR MAINSUBJECT.EXACT("Autism") OR MJMESH.EXACT("Asperger Syndrome") OR ABSTRACT,TITLE(autism*) OR ABSTRACT,TITLE(autistic*)*	**1794**	**1520**

		AND *MJMESH.EXACT("Multilingualism") OR MAINSUBJECT.EXACT("Bilingual materials") OR MAINSUBJECT.EXACT("Bilingual education") OR MAINSUBJECT.EXACT("Bilingualism") OR MAINSUBJECT.EXACT("Second language learning") OR MAINSUBJECT.EXACT("English as a second language") OR MAINSUBJECT.EXACT("French as a second language") OR MJMESH.EXACT("Language Therapy") OR MJMESH.EXACT("Language Development") OR ABSTRACT,TITLE(code-switching) OR ABSTRACT,TITLE(interlanguage) OR ABSTRACT,TITLE(bilingual) OR ABSTRACT,TITLE(two languages) OR ABSTRACT,TITLE(dual language)* *1990 – present*		
6	PubMed	**(#1 AND #2) AND (("1990"[Date - Publication] : "3000"[Date - Publication]))** *("Autistic Disorder"[MeSH Major Topic] OR "Autism Spectrum Disorder"[MeSH Major Topic] OR "Asperger Syndrome"[MeSH Major Topic] OR "autism*"[Text Word] OR "autistic*"[Text Word] OR "ASD"[Text Word]) AND ("Multilingualism"[MeSH Terms] OR "Bilingual Education"[Text Word] OR "Second Language"[Text Word] OR "language second"[Text Word] OR "L2"[Text Word] OR "Code-Switching"[Text Word] OR "Interlanguage"[Text Word] OR "Bilingual Education"[Text Word] OR "Bilingual"[Text Word] OR "Language Acquisition"[Text Word] OR "Dual language"[Text Word] OR "Two languages"[Text Word]) AND 1990/01/01:3000/12/31[Date - Publication]*	**365**	**365**
7	Scopus Preview	*(TITLE-ABS-KEY ("Autistic Disorder") OR TITLE-ABS-KEY ("Autism Spectrum Disorder") OR TITLE-*	**619**	**306**

		ABS-KEY ("Asperger Syndrome") OR TITLE-ABS-KEY ("autism") OR TITLE-ABS-KEY ("autistic*") OR TITLE-ABS-KEY ("ASD")) AND (TITLE-ABS-KEY ("Multilingualism") OR TITLE-ABS-KEY ("Bilingual Education") OR TITLE-ABS-KEY ("Second Language") OR TITLE-ABS-KEY ("language second") OR TITLE-ABS-KEY ("L2") OR TITLE-ABS-KEY ("Code-Switching") OR TITLE-ABS-KEY ("Interlanguage") OR TITLE-ABS-KEY ("Bilingual") OR TITLE-ABS-KEY ("Language Acquisition") OR TITLE-ABS-KEY ("Dual language") OR TITLE-ABS-KEY ("Two languages")) AND PUBYEAR > 1989 AND PUBYEAR < 3001*		
	Personal Search	*"bilingualism effects in autism"*	**2**	**2**
Total of results			**5,273**	
Number of duplicated detected			**868**	
Total of results screened			**4,405**	

Thanks to the tools provided by each database, an excel file with the results was extracted and later undertook a duplicate test in order to avoid re-examining the same articles. As shown in Table 2, a number of 868 duplicate articles were identified and removed. The final number of articles screened was 4,405.

2.3. ASReview LAB

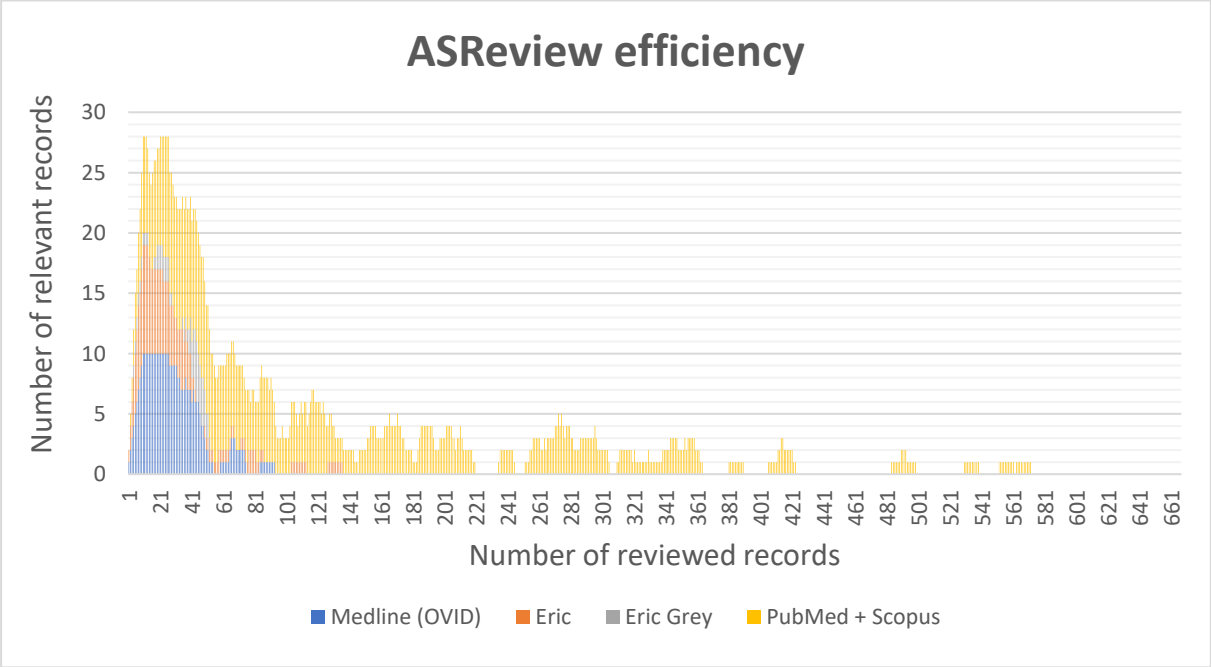
Undoubtedly, the progression of artificial intelligence stands as one of the most significant advancements in recent human history, leading to the development of numerous software tools aimed at aiding reviewers in conducting systematic reviews. A notable example, and one used during this thesis' systematic review, is ASReview LAB. ASReview LAB is an open-source software that combines machine learning and the reviewer's responses in order to automatically provide studies that are most relevant to the research question. As described by Van de Schoot et al. (2021, p. 127): "The goal of ASReview is to help scholars and

practitioners to get an overview of the most relevant records for their work as efficiently as possible while being transparent in the process.".

Following installation, the extracted Excel documents from each database containing the titles and abstracts of all articles were inputted into ASReview. As requested by the software, some relevant studies were provided as background information in order to facilitate the machine learning process before screening. After putting this software to the test, I can confirm that it was incredibly effective when it comes comprehending the concepts linked to the research question, as it adeptly presented only pertinent studies at the onset of the scanning process. Nonetheless, it is understandable that machine learning is not absolute. In order to avoid any errors, I reviewed and verified every study and managed to uncover some relevant studies that ASReview initially deemed irrelevant. ASReview additionally provide charts regarding its effectiveness in detecting relevant studies.

Since each database was calculated separately, ASReview only provided charts on its efficiency per database. In order to avoid adding to much information I extracted the data behind these graphs in excel and created one general graph including all databases (Figure 2)

Figure 2 *ASReview efficiency*



2.4. Selection Criteria

During screening in ASReview LAB, only the title and abstract were reviewed. In order to conduct a coherent search, a number of selection criteria was predefined. The following table (Table 3) demonstrates the inclusion as well as exclusion criteria used during the first screening process:

Table 3 *Selection criteria*

Inclusion Criteria:	**Exclusion Criteria:**
- Studies that include individuals diagnosed with ASD. - Studies that investigate the effects of bilingualism on individuals diagnosed with ASD. - Studies that involve participants of any age with a confirmed diagnosis of ASD. - Studies that explore bilingual home environments with individuals with ASD. - Studies that explore the relationship between bilingualism and various outcomes related to ASD, such as language development, cognitive abilities, social skills, or executive function. - Studies that present empirical data or quantitative measures to assess the impact of bilingualism on autistic individuals.	- Studies focusing solely on neurotypical individuals or individuals without a confirmed diagnosis of ASD. - Studies with the perspectives of parents and practitioners. - Studies exploring the effectiveness of interventions. - Studies examining language acquisition. - Review articles, opinion pieces, editorials, or conference abstracts. - Studies lacking relevant outcomes or measures related to bilingualism and its effects on ASD. - Conditions comorbid to ASD. - Studies including participants with ASD as well as other medical conditions. - Studies without control groups

- Parent ratings through empirical forms. - Studies comparing bilingual and monolingual ASD individuals - Studies comparing typically developing bilinguals with autistic bilinguals.	- Studies comparing autistic and typically developing monolinguals only.
Key terms: *ASD, autism, bilingualism, bilingual environment, language development, linguistic, cognitive abilities, adaptive function, social skills, or executive function.*	Key terms: *Opinions, perceptions, comorbidities, language acquisition, effectiveness of interventions, no confirmed diagnosis, potential ASD.*

2.5. Coding Procedures

After the initial systematic review in ASReview LAB was completed, a coding guide was put in place in order to better organise the second stage of screening of the included literature. The coding guide is a tool used by researchers in order to gather information that will later be used in their meta-analysis. The employment of a coding guide in this study draws significant inspiration from Cooper's pivotal work, "Research Synthesis and Meta-Analysis: A Step-by-Step Approach" (2010). This guide has proved invaluable in facilitating the coding process and enhancing the organization of data. The initial structure of the coding guide was heavily inspired by Cooper's suggested classification: 1. The report, 2. The predictor or independent variable, 3. The setting in which the study took place, 4. Participant and sample characteristics, 5. The dependent or outcome variables and their measurement, 6. The type of research design, 7. Statistical outcomes and effect sizes, and 8. Coder and coding process characteristics (2010, p. 130-131).

Numerous adjustments were implemented in order to better support my study and its specific requirements. The tool which I decided to use for my coding guide was a Microsoft Forms questionnaire. The selection of a Microsoft Forms questionnaire as the preferred tool for

developing my coding guide was primarily motivated by its accessibility as well as its widespread recognition within academic circles. Additionally, Microsoft Forms allows a plethora of question types, restrictions, relationships between given answers and finally automated statistics in the results page.

The coding guide used in this study consists of thematical sections that more adequately relate to the research question and the data needed in order to conduct a meta-analysis in a later stage. The first section interrogates on the inclusivity of the given study and the reason behind excluded studies. The reasoning behind this section is the opportunity to include in the results of the coding guide studies which were excluded and the reasoning behind their exclusion. Later more standardised sections focus on report characteristics, setting characteristics as well as participant and sample characteristics based on ASD and bilingualism. The final sections delve into the quality assessment of included studies, the effects of bilingualism and finally the numerical values of effect sizes.

2.6. Quality assessment of included studies

In order to conduct a qualitative analysis, it was essential to consider potential biases in the studies collected. Thus, a list of different types of bias were identified and examined throughout the meta-analysis. This thesis' approach to quality assessment was highly influenced by Sandbank et al.'s article: "Project AIM: Autism intervention meta-analysis for studies of young children" (2020).

Key quality indicators derived directly from the article included "Random Assignment", distinguishing between randomized control trials and quasi-experimental studies; "Independence of Assessors", focusing on whether the assessors were previously familiar with the participants; "Incomplete Outcome Data", concerning outcomes that were collected but not fully reported; "Boundedness", which refers to the context of the intervention, either context-bound (conducted in a familiar environment with known objects and people) or reflecting generalised change (using unfamiliar materials or examiners across diverse contexts); and "Distality", addressing whether the intervention effects were directly taught or

occurred as developmentally downstream impacts. These indicators were critical in assessing the quality and potential biases of the studies included in the analysis.

In addition to adopting the quality indicators outlined by Sandbank et al., I incorporated several of my own criteria to enhance the reliability in this thesis. One such indicator is whether the study was peer-reviewed, a critical factor in understanding whether the study was verified by specialised lecturers. Another interesting indicator focuses on experience with autism; it questions whether researchers had firsthand experience with autism and autistic individuals, which can influence the depth of understanding and sensitivity in the study design and interpretation. Funding is also considered, noting whether the study received financial support that could impact its scope. Lastly, the setting consistency between the treatment and control groups was evaluated to ensure that both groups were examined in the same environment, ensure reliable outcome data. These added indicators were vital in creating a comprehensive bias check for the included studies and generated useful results.

2.7. Definition of Independent and Dependent Variables

In my study, the primary independent variable is bilingualism, which refers to whether an individual is bilingual. I consider autism to be an additional independent variables since besides examining the effect of bilingualism I also took advantage of my collected data to compare autistic individuals to neurotypical ones. The dependent variables are the four key outcomes that may be influenced by bilingualism in autistic individuals or by autism itself: cognitive abilities, adaptive functioning, social-communication skills, and linguistic outcomes. Each of these dependent variables will be measured to assess how they are affected by the presence of bilingualism and, potentially, the interaction with autism.

2.8. Outcome Characteristics

Each relevant study was analysed in order to determine which outcome characteristic best fitted its effect sizes. This decision was mostly made through the explanations given by the researchers themselves or by verifying the notions behind a chosen check lick/test.

Some of the most important types of testing related to the cognitive outcome include:
Sentence repetition, set-shifting, card sort task (measured for accuracy and response time), working memory, cognitive domain, ToM assessment, executive function, fine motor, arithmetic, world recall and so on.

Adaptive functioning included less but well-defined outcome subtypes:
Social skills, stereotypical behaviour, social responsiveness, coping skills, play and leisure, aggressive behaviour etc.

In order to examine outcome effects on social-communication the following subtypes were chosen:
Social problems, expressive language, relations, communication, expressive vocabulary and so on.

Finally linguistic outcome types focus mainly on language skills:
Syntax, Vocabulary, verbal working memory, morphology, reading comprehension, expressive and receptive language, writing ability, number of correct words etc.

2.9. Aggregating Effect Sizes

After extracting the excel file of the final relevant studies, Cohen's d was calculated in Microsoft Excel. Using the Treatment group's sample size (n), mean and SD, the effect sizes were calculated automatically using the formula for Cohen's d. Thanks to useful information on the matter online I managed to extract Cohen's d automatically using Excel through specific calculations (Bobbitt, 2020).

To calculate Cohen's d using Excel, I started by determining the difference between the means of two groups, which involves simply subtracting the mean of Group 2 from the mean of Group 1. Next, I calculated the pooled standard deviation, a crucial step for understanding the

overall variability between these groups. This is done by a pre-defined formula which I took from Cooper (2010, p. 226):

$$SD_{\text{within}} = \sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}}$$

Finally, Cohen's d is obtained by dividing the mean difference by this pooled standard deviation. The following formulas were used in Excel:

Mean 1 – Mean 2
=[@[Group 1 M]]-[@[Group 2 M]]

Pooled ds
=SQRT((([@[Group 1 N]]-1)*[@[Group 1 SD]]^2+([@[Group 2 N]]-1)*[@[Group 2 SD]]^2)/([@[Group 1 N]]+[@[Group 2 N]]-2))

Cohen's d
=[@[m1-m2]]/[@[pooled sd]]

2.10. Meta-Analysis

I employed the metafor package in RStudio in order to successfully conduct a meta-analysis. This package is specifically designed for meta-analysis and includes functions for calculating weighted effect sizes and synthesizing findings from a collection of studies. I started by compiling data from studies that fit my criteria, including effect sizes and variances. I then input these into RStudio, where metafor helped me continue the process. After calculating the standard error for Cohen's d, I created different subgroups and conducted the meta-analysis while also generating forest plots in order to better visualise the different effect sizes between groups and per outcome. All these calculations were successfully employed thanks to Harrer et al.'s in-depth guide on conducting a meta-analysis in R Studio (2021) as well as online Q&A forums.

2.11. Thesis repository

All the tools, code and documents extracted throughout this thesis have been uploaded on my personal GitHub account in case of interest:

https://github.com/svalmara/MEMO-B540/tree/main

3. Results

This section will focus on a comprehensive summary of results obtained through out the coding and screening process. This overview will present the demographic and outcome data extracted from the meta-analysis examining the effects of bilingualism in ASD. Furthermore, a description of the results on detection bias will help better understand the possible risks that may have influenced the results in this meta-analysis. Finally, after a look into the effect sizes generated between different groups and outcomes, this section will conclude with a note on heterogeneity and publication bias.

3.1. Summary of result demographics and outcomes

In the process of identifying relevant literature, I managed to extract studies from six databases: EBSCO (2,011 records), ERIC (211 records), Ovid MEDLINE (271 records), ProQuest (1,794 records), PubMed (365 records), and Scopus (619 records). Personal searches yielded two additional studies. Before screening, 868 duplicate records were removed, leaving 4,405 studies for the main screening process in ASReview LAB. The final result of relevant studies was 131 out of which 6 could not be retrieved for further analysis. The remaining 125 reports were assessed for eligibility, with several being excluded due to various reasons: absence of a control group (3 reports), insufficient data (21 reports), studies on language acquisition (5 reports), studies on interventions (13 reports), biased outcomes and/or studies on perceptions and opinions (11 reports), systematic reviews (7 reports), presence of comorbidities (3 reports), and other non-specified reasons or mistakes (12 reports). Ultimately, 38 studies met the inclusion criteria and were included in this meta-analysis. Figure 3 provides an overview of the information provided above, with the now filled PRISMA 2020 flow chard.

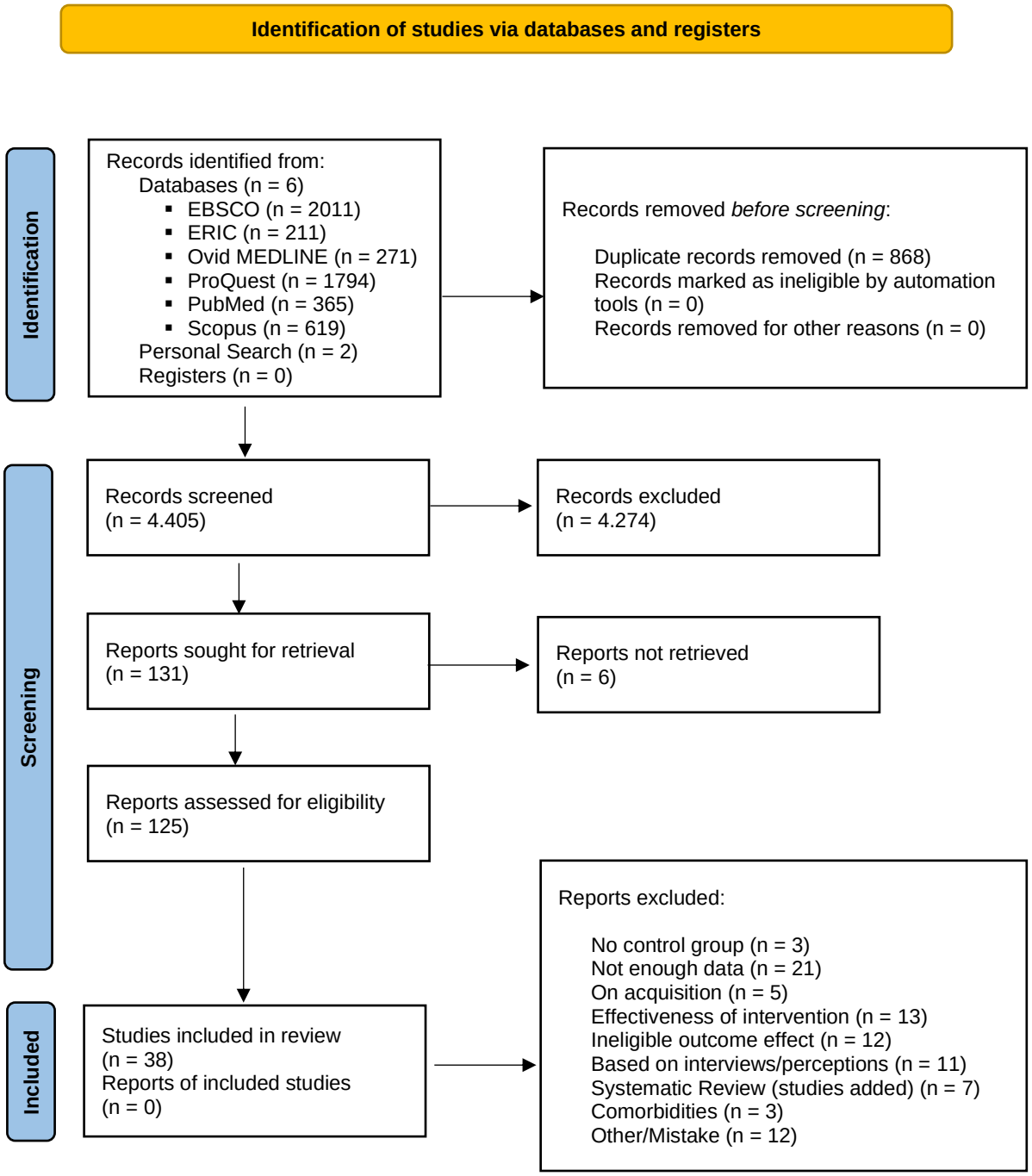
The final 38 included studies produced a total of 456 effect sizes between several group comparisons, representing 3,491 participants. From these participants, 1,241 where ASDB, 1,588 ASDM, 429 TDB and 233 TDM. The predominant age range amongst participants was 6-12 years old with most of them being male, the mean percentage being approximately

80.26%. 19 studies were included for the analysis of cognitive outcomes, 11 for adaptive functioning, 30 for social-communication and 29 for linguistic. The table below illustrated the number of languages and countries involved in the 38 included studies as well as their frequencies.

Table 4 *Countries and languages involved*

Language	**Frequency**	**Country**	**Frequency**
English	*37.5%*	**Canada**	*N = 12 - 31.58%*
Greek	*14.58%*	**US**	*N = 9 - 23.68%*
French	*12.5%*	**Greece**	*N = 7 - 18.42%*
Other	*8.33%*	**Singapore**	*N = 2 - 5.26%*
Chinese	*6.25%*	**Hong Kong - China**	*N = 2 - 5.26%*
Spanish	*6.25%*	**Israel**	*N = 2 - 5.26%*
Hebrew	*4.17%*	**United Arab Emirates**	*N = 1 - 2.63%*
Russian	*4.17%*	**Australia**	*N = 1 - 2.63%*
Arabic	*2.08%*	**UK**	*N = 1 - 2.63%*
Catalan	*2.08%*	**Spain**	*N = 1 - 2.63%*
Cantonese	*2.08%*		

Figure 3 *PRISMA 2020 flow diagram filled*



3.2. Detection Bias

Detection bias was calculated in order to better understand and verify the background of each study. As previously explained in my methodology (See Section 2.6.), bias was calculated based on a number of study characteristics:

- Peer-reviewed: Whether the study was peer-reviewed
- Experience with autism: Whether the researcher was experienced with autism and autistic individuals firsthand
- Funding: Whether the study was financed
- Setting: Whether the setting of the treatment group was the same as the control group
- Design type bias: Randomised controlled trials (RCT) vs Quasi-Experimental
- Incomplete outcome data: Whether outcomes collected but partially reported
- Independence of assessors: Whether the reporters/researchers were already familiar with the participants
- Boundedness: Whether the intervention/test trials were conducted in a controlled and unfamiliar environment or in a familiar environment to the participants.
- Proximity/Distality: Whether the results used to calculate effect sizes were collected in a short period of time or overtime.

3.2.1. Description of detection bias results for all included studies

The detection bias results for all included studies can be found in Figure 4:

Figure 4 *Detection Bias for all Included Studies*

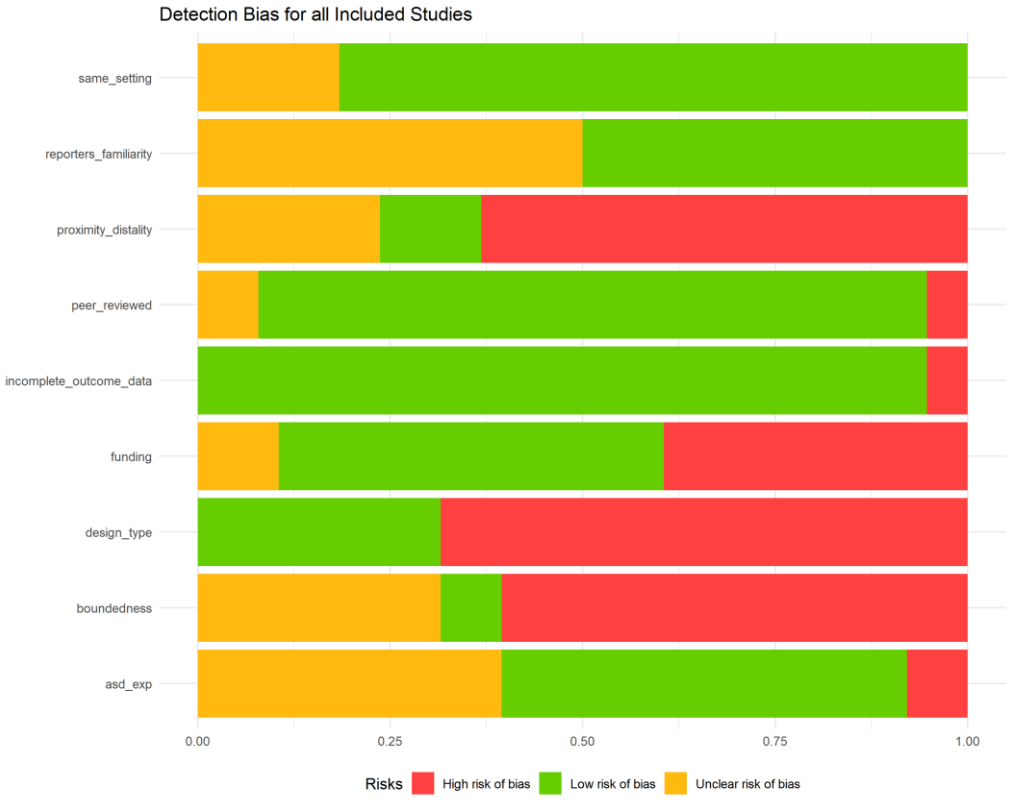


Figure 4 illustrates significant variations across different quality indicators. Out of the 38 studies included in the study, 2 of them were not peer reviewed (86.842%), 3 were found to be unclear (7.895%) and the majority of 33 studied were determined peer-reviewed (5.263%). Half of the researchers involved were proven to be experienced with autism firsthand (52.632%), while the rest were either found with unclear experience (39.474%) or without any (7.895%). 15 studies described being financed (39.474%), while 50% weren't using funds and 4 were unclear (10.526%) on the matter. Most studies reflected low risk of bias regarding setting where both control and treatment groups were examined in similar settings (81.579%), while 7 studies weren't (18.421%). Design type bias reveals a considerable proportion of studies (76.02%) exhibited a high risk of bias concerning their design type with most employing a quasi-experimental model. The latter further proves what has been previously reported in the literature: "randomized tests of interventions have been exceptionally rare in ASD research" (Sandbank et al., 2020, p. 16, citing Warren et al., 2011). Only 2 studies were missing some core outcome data and the rest 94.74% were complete, revealing a statistically low risk of bias. Concerns regarding the familiarity of reporters were noted, unclear and low risk of bias both represented half of the studies included. These results illustrate that a significant number of studies were unclear regarding the familiarity between participants and reporter/interviewers, which is an important issue. Regarding boundedness, most studies were unclear (31.579%) or found to use familiar environments (60.526%) in their intervention/testing process. The remaining 7.895% successfully conducted their testing in a controlled environment. Finally, the majority of studies conducted testing within a short period of time (63.158%), showing a high risk of proximity bias. While only 13.158% show low risk of bias, another 23.684% remained unclear. These findings suggest a varied landscape of bias risks across different indicators. Particularly, the high risk in boundedness, design type and proximity measures may notably skew study results, necessitating more thorough examination and enhancements in methodological approaches in future research.

3.3. Effect Sizes per Outcome and between different groups

In order to better understand the effects of bilingualism in ASD individuals, effect sizes were compared between different groups as well as outcome types. The groups compared in this meta-analysis are the following:

- ASDB – ASDM: Bilinguals versus monolinguals with autism
- ASDB – TDB: Bilinguals with autism versus typically developing bilinguals
- ASDM – TDM: Monolinguals with autism versus typically developing monolinguals
- ASDBH – ASDM: High bilinguals with ASD compared to ASDM
- ASDL – ASDM: Low bilinguals with ASD compared to ASDM
- ASDSEQ – ASDM: Sequential bilinguals with ASD compared to ASDM
- ASDSIM – ASDM: Simultaneous bilinguals with ASD compared to ASDM

Each subgroup was firstly analysed in its totality without filtering outcomes and by each one of the four outcome types already discussed:

- Cognitive
- Adaptive functioning
- Social-Communication
- Linguistic

This section will present the results obtained in total and by outcome type between several subgroup comparisons when available.

3.3.1. Results per group without separation of outcome types

3.3.1.1. ASDB compared to ASDM

Figure 5 is a forest plot illustrating the different effect sizes recorded amongst all studies when comparing ASDB to ASDM. Each horizontal line represents a study, with the point indicating the estimated effect size (Cohen's d) and the lines representing the 95% confidence intervals (CIs). The majority of studies have effect sizes ranging from slightly negative to

moderately positive. Two lines demonstrate a significantly negative effect and will be discussed in a later stage. The pooled effect size (Cohen's d) for the difference between ASDB and ASDM was estimated at 0.1156, with a standard error of 0.0382. The confidence interval for this estimate ranges from 0.0406 to 0.1905, and the p-value effect was significant (p = 0.0025). This suggests a small to moderate positive effect of bilingualism for autistic individuals.

3.3.1.2. ASDB compared to TDB

Figure 6 demonstrates the different effect sizes recorded amongst all studies when comparing ASDB to TDB. Each horizontal line represents a study, with the point indicating the estimated effect size (Cohen's d) and the lines representing the 95% confidence intervals (CIs). Effect sizes vary widely across studies, with Cohen's d values ranging from approximately from -2 to +3, with most indicating moderate diagnostic effect.

3.3.1. Results per Outcome between different groups

3.3.1.1. Cognitive effects of bilingualism (ASDB – ASDM)

Analysing the impact of bilingualism on a cognitive level, Figure 7 provides an overview of the different effect sizes between ASDB as the treatment group and ASDM the control group. Each horizontal line corresponds to a specific outcome subtype tested by a given study whose ID number and publication year are specified in the first two columns. The squares on the plot represent the mean effect sizes estimated for each testing. Furthermore, at the bottom, the diamond shape summarizes the combined effect of all studies. Notably, the range of Cohen's d effect sizes spans from -2 to +2, resting at the mean effect size of 0.28. This central value suggests a small but positive cognitive effect of bilingualism on autistic individuals who are bilingual, in comparison to those who are monolingual.

3.3.1.2. Cognitive effects of bilingualism (ASDB – TDB)

Another overlapping comparison in the literature was between ASDB and TDB. Where the central value (represented one more by the diamond shape) centring at -0.18. The latter indicating a small negative cognitive effect of autistic bilinguals compared to typically developing ones (see Figure 8).

3.3.1.3. Cognitive effects of bilingualism (ASDM – TDM)

Although not directly linked to my research question, it is interesting to look into ASDM performance in all outcomes. This allows a better comparing between the ASDB group and ASDM group, given they were analysed with similar control groups. As shown in Figure 9, the comparison between ASDM and the corresponding TDM revealed a large negative mean cognitive performance (-0.89).

3.3.1.4. Cognitive effects of bilingualism (ASDM – TDB)

In order to compare cognitive performances between ASDB and ASDM, ASDM were also compared to TDB. As illustrated in Figure 10, ASDM performed a lot lower than TDB, compared to ASDB, given the medium mean effect size of -0.55.

3.3.2.1. Adaptive functioning effects of bilingualism (ASDB – ASDM)

Figure 11 pictures the different effect sizes in adaptive functioning between ASDB and ASDM. The small negative mean effect of -0.14 indicates little to no influence of bilingualism in adaptive functioning.

3.3.2.2. Adaptive functioning effects of bilingualism (ASDB – TDB)

When compared to TDB, ASB performed unexpectedly higher, with a positive mean effect size of 0.49, as shown in Figure 12.

3.3.2.3. Adaptive functioning effects of bilingualism (ASDBH – ASDM)

One study explored the differences between ASDBH and ASDM in adaptive functioning. ASDB proved to have a less negative mean effect size than ASDB (-0.10) as depicted in Figure 13.

3.3.2.4. Adaptive functioning effects of bilingualism (ASDBL – ASDM)

ASDBL scored lower than both ASDB and ASDBH when compared to ASDM with a medium negative mean effect size of -0.33 (see Figure 14).

3.3.2.5. Adaptive functioning effects of bilingualism (ASDM – TDB)

Once again, ASDM like ASDB performed higher than TDB. A less striking but nevertheless positive mean effect of 0.17 was observed (see Figure 15).

3.3.2.6. Adaptive functioning effects of bilingualism (ASDM – TDM)

An almost similar mean effect was calculated for ASDM compared to TDM in adaptive functioning, where the mean effect was 0.12 (Figure 16).

3.3.3.1. Social-Communication effects of bilingualism (ASDB – ASDM)

Figure 17, listing the different effects of bilingualism regarding social-communicative tasks, presents for the first time an almost null mean effect size. The mean effect size is slightly positive, 0.02, showing little to no advantages of bilingualism between ASDB and ASDM in social and communicative performance.

3.3.3.2. Social-Communication effects of bilingualism (ASDB – TDB)

Five studies revealed a small but still impressive positive mean effect size (0.25) as found in Figure 18.

3.3.3.3. Social-Communication effects of bilingualism (ASDBH – ASDM)

ASDBH groups generated a small negative mean effect size (-0.10) when compared to ASDM, as shown in Figure 19.

3.3.3.4. Social-Communication effects of bilingualism (ASDBL – ASDM)

A small to medium negative effect size (-0.33) was observed between ASDBL and ASDM in adaptive functioning.

3.3.3.5. Social-Communication effects of bilingualism (ASDBSEQ – ASDM)

ASDBSEQ compared to ASDM resulted in a small to medium negative mean effect size: -0.29 (see Figure 21)

3.3.3.6. Social-Communication effects of bilingualism (ASDBSIM – ASDM)

An almost null mean effect (0.04) was generated in adaptive functioning between ASDBSIM and ASDM as illustrated in Figure 22.

3.3.3.7. Social-Communication effects of bilingualism (ASDM – TDB)

When comparing social-communication abilities between ASDM and TDB groups, four studies lead to an almost null mean effect size, 0.03 (Figure 23).

3.3.3.8. Social-Communication effects of bilingualism (ASDM – TDM)

In contrast to the comparison of ASDM to TDB, when compared to TDM, ASDM scored significantly lower. A medium mean effect size of -0.56 was calculated between ASDM and TDM as shown in Figure 24.

3.3.4.1. Linguistic effects of bilingualism (ASDB – ASDM)

The forest plot in Figure 25 compares the linguistic performances between ASDB and ASDM across several studies. Despite two significantly negative effect sizes, the mean effect size stayed at a rather small but negative effect: -0.10.

3.3.4.2. Linguistic effects of bilingualism (ASDB – TDB)

Surprisingly, when analysing linguistic performance between ASDB and TDB, an insignificant but positive mean effect of 0.08 was calculated (Figure 26).

3.3.4.3. Linguistic effects of bilingualism (ASDBH – ASDM)

Figure 27 presents important positive effects between ASDBH and ASDM, where ASDBH presented a positive mean effect size of 1.14 in linguistic performances.

3.3.4.4. Linguistic effects of bilingualism (ASDBL – ASDM)

ASDBL scored lower but still incredibly well when compared to ASDM. In Figure 28 we see a mean effect size of 0.36, indicating medium effect of bilingualism in linguistic capabilities.

3.3.4.5. Linguistic effects of bilingualism (ASDBSEQ – ASDM)

Figure 29 presents important negative effects between ASDBSEQ and ASDM, where ASDBSEQ presented negative effect sizes between -0.62 and -0.06, resulting in medium negative mean effect of -0.34 in linguistic performances.

3.3.4.6. Linguistic effects of bilingualism (ASDBSIM – ASDM)

Surprisingly ASDBSIM performed better than ASDSEQ in comparison to ASDM. Figure 30 shows a small positive mean effect of 0.10 in linguistic abilities.

3.3.4.7. Linguistic effects of bilingualism (ASDM – TDM)

When compared to TDM, ASDM generated a large negative mean effect (-0.93), as demonstrated in Figure 31.

3.3.4.8. Linguistic effects of bilingualism (ASDM – TDB)

Figure 32 demonstrates that when compared to TDB, ASDM performed significantly lower with a medium negative mean effect of -0.42.

3.4. Heterogeneity

The analysis included 233 observations, and the results indicate substantial heterogeneity among the studies as shown by the high I^2 value, indicating that 83.97% of the total variability in effect sizes across studies is due to heterogeneity rather than sampling error. The tau^2 value, an estimate of the amount of total heterogeneity, was 0.2491, suggesting significant variability among the true effect sizes of the studies.

3.5. Publication Bias

Publication bias was assessed using a funnel plot and an Egger's regression test. The test for funnel plot asymmetry was significant: t = -2.4020, df = 231, p = 0.0171, indicating potential publication bias which may have impacted the meta-analysis. Figure 33 provides a visual representation of the funnel plot. The horizontal axis represents Cohen's d values measuring the difference in means between treatment and control groups. While vertical axis indicates the standard error of each study's effect size. Smaller studies with larger standard errors position themselves higher on the plot while larger studies appear lower on the plot due to their small standard errors. When analysing the funnel plot two main observations can be made. On the one hand, there is a clear asymmetrical distribution amongst studies, suggesting a considerable rick of publication bias. On the other hand, this risk is enhanced by the presence of outliers which are studies with extreme effect sizes positioned further away from the clustered studies near 0. The latter is a crucial issue that may have impacted the overall meta-analysis results.

4. Discussion

4.1. Discussion on the results of cognitive outcomes

In the exploration of cognitive effects of bilingualism among autistic individuals, the results present a complex interaction between autism, bilingualism, and cognitive outcomes. Analysing different group comparisons provides a comprehensive picture. The meta-analysis indicates a slight but positive cognitive benefit of bilingualism for autistic individuals who are bilingual (ASDB) compared to their monolingual counterparts (ASDM), with a mean effect size of 0.28. This suggests that bilingualism may foster cognitive resilience or enhanced executive functioning in autistic individuals due to the cognitive demands of managing two languages.

However, when comparing ASDB to TDB, the results shift to a negative effect, with mean effect sizes of -0.18. These results demonstrate that despite the potential cognitive benefits of bilingualism within the context of autism, typical development or other developmental conditions show to possess stronger cognitive advantages, compared to autistic bilinguals. It is important to note that the mean effect of -0.18 is considered of small to medium significance in Choen's d standards.

Further complexities are evident when ASDM are considered. The comparisons of ASDM with TDM and TDB show significant cognitive disadvantages of diagnosis, with large negative effect sizes of -0.89 and -0.55, respectively. This underlines a more pronounced cognitive impact of autism itself, suggesting that the absence of bilingualism increases cognitive deficits.

These findings lead to a better understanding of the nuanced interplay between autism, bilingualism, and developmental conditions and cognitive outcomes. They suggest that bilingualism offers a moderate cognitive advantage to autistic individuals. This advantage becomes clearer considering the moderately positive mean effect of bilingualism in autism (0.28). Additionally, comparisons between autistic groups and their counterparts (ASDB-TDB and ASDM-TDM) reveal that autistic bilinguals show a less pronounced negative effect size

of -0.18, contrasting sharply with the significantly larger negative effect size of -0.89 observed in their monolingual counterparts.

4.2. Discussion on the results of adaptive functioning outcomes

The analysis of adaptive functioning effects of bilingualism offered a more varied insight across several different autistic and typically developing groups. Although its smaller presence in the literature, a significant number of effect sizes managed to paint a bigger picture. In the comparison between ASDB and ASDM, the small negative mean effect of -0.14, as shown in Figure 11, suggests that bilingualism has little to no impact on the adaptive functioning in autistic individuals. This result, however, indicates that bilingualism, despite its cognitive benefits, may not significantly enhance adaptive behaviours.

In a surprising contrast, when ASDB are compared to TDB, they demonstrate superior adaptive functioning performance, with a positive mean effect size of 0.49, as depicted in Figure 12. Similarly, ASDM also outperformed TDB and TDM with the less pronounced positive mean effect sizes of 0.17 and 0.12 respectively (see Figures 15 and 16).

Looking into ASDBH and ASDBL comparisons to ASDM both groups generated small to medium mean effect sizes in adaptive functioning. Unsurprisingly, ASDBH presented a small negative mean effect size of -0.10 while ASDBL a medium mean effect of -0.33. This suggest that ASDM may perform better in adaptive behaviour compared to ASDBH and ASDBL but ASBH show that a better bilingual proficiency may have given them an advantage over ASDBL.

These findings highlight that while bilingualism does not drastically improve adaptive functioning in autistic individuals, they seem to exhibit adaptive functioning that is unexpectedly effective, irrespective of their bilingual status. The only difference being ASDB scoring significantly higher than ASDM when compared to their typically developing counterparts, 0.49 to 0.12 respectively.

4.3. Discussion on the results of social-communication outcomes

Exploring the social-communication effects of bilingualism on autistic individuals illustrates varying impacts across a significant number of different comparisons, adding sequential and simultaneous bilinguals to the list. The forest plot in Figure 17 examines the difference in social-communicative performance between ASDB and ASDM, uncovering an almost null mean effect size of 0.02. This indicates that bilingualism provides little to no advantage in social and communicative tasks within this autistic subgroup, suggesting that the potential cognitive benefits of bilingualism may not extend significantly into social-communication domains for these individuals.

Moving to the comparisons involving typically developing groups, ASDB compared to TDB display a small but interesting positive mean effect size of 0.25. In contrast, when ASDM are compared with the same TDB, the mean effect size is almost null (0.03), compared to the overall moderate mean effect size of 0.25 for the ASDB group. However, a more pronounced difference emerges when ASDM are compared to their TDM counterpart. Figure 24 reveals a medium to large negative mean effect size of -0.56, indicating a significant disadvantage for autistic monolinguals in social-communication abilities relative to their typically developing monolingual counterparts. This suggests that while autistic bilinguals performed relatively well compared to their typically developing counterparts (0.25), autistic monolinguals generated a large negative mean effect size (-0.56) when compared to TDM.

Similarly to adaptive functioning, ASDBH and ASDBL both generated negative small to medium mean effect sizes when compared to ASDM. Unsurprisingly, ASDBH presented a small negative mean effect size of -0.10 while ASDBL a medium mean effect of -0.33. The latter being expected since these two cases were determined in the coding process as both social-communicative and adaptive.

Furthermore, interesting results arose from the comparisons between ASDBSEQ and ASDBSIM with ASDM. ASDSIM generated an almost null mean effect size (0.04), while ASDBSEQ a medium negative mean effect of -0.29, as shown in Figures 21 and 22

respectively. These results, correspond to the belief that learning a second language simultaneously will provide a more harmonious language development. These results show a small to medium advantage of simultaneous bilingualism compared to a sequential one.

Overall, these findings illustrate an interesting analysis how bilingualism interacts with autism and typical development in the domain of social-communication. The subtle positive effects for autistic bilinguals when compared to typically developing bilinguals might reflect nuanced benefits of bilingualism in autism, yet these are not strong enough to make a general assumption. Most interestingly, ASDSIM proved to perform better than ASDSEQ when compared to ASDM, further proving the effectiveness of bilingualism as well as the simultaneous approach.

4.4. Discussion on the results of linguistic outcomes

Linguistic effects of bilingualism on autistic individuals were compared between eight different groups. In the comparison between ASDB and ASDM, shown in Figure 25, there is a small negative mean effect size of -0.10. This result suggests that bilingualism does not offer significant linguistic benefits to autistic individuals compared to their monolingual peers and may in some instances slightly delay linguistic performance.

In the broader context of comparisons with TDB, ASDB generated an insignificant but slightly positive mean effect size of 0.08, as illustrated in Figure 26. This could imply that autistic bilinguals manage to perform similarly to typically developing bilinguals, suggesting a potential levelling effect of bilingualism on linguistic skills despite autism.

Similar results reoccur regarding ASDBH and ASDBL. Once again, ASDH scored largely better compared to ASDM (1.24), while ASDBL generated a still impressive positive medium mean effect (0.36). Similarly to Social-communication outcomes, ASDBSIM prevailed over the ASDSEQ group when compared to ASDM. While ASDBSEQ resulted in the medium negative mean effect of -0.34 (see Figure 29), ASDBSIM generated an almost null but

positive mean effect size (0.10). These results further prove the effectiveness of bilingual proficiency for autistic individuals.

Moreover, when examining the performance of ASDM across different groups, there are additional complexities. ASDM, when compared to their typically developing counterparts (TDM), exhibit a large to very large - negative mean effect (-0.93, see Figure 31), suggesting pronounced linguistic deficits. Similarly, when compared to TDB, ASDM scored a smaller but still negative mean effect size of -0.42, as shown in Figure 32. This points to a broader pattern where autistic monolinguals consistently demonstrate lower linguistic performances when compared to other groups, emphasizing the profound impact of autism on linguistic abilities.

Overall, these findings demonstrate complex relations between bilingualism autism and typical development in the linguistic domain. Notably, this meta-analysis demonstrated that bilingualism doesn't appear to cause an impact on linguistic performance given the small to null mean effects of -0.10 and 0.08. Furthermore, ASDBSIM and ASDBH generate continuously higher mean effect sizes compared to ASDSEQ and ASDBL. While on the other hand, the large mean effect size of -0.93 produced by ASDM suggests a significant diagnostic effect, indicating that autism may cause particular linguistic deficits.

4.5. Implications of the findings for theory, practice, and future research.

Theoretically, these results refine our understanding of how bilingualism interacts with autism, suggesting that the benefits of bilingualism are not universal but may depend on specific cognitive, adaptive, social contexts and linguistic contexts. Practically, the data collected may inform educators, clinicians, and caregivers about the potential benefits of promoting bilingual environments for autistic individuals. Given the complexity within the results, it is suggested that a personalized approach be used, where the individual's specific abilities and challenges are considered and worked upon.

Future research should continue to dissect these relationships, perhaps focusing on longitudinal studies that can capture the long-term effects of bilingualism in autistic populations. This comprehensive analysis across multiple domains clearly demonstrates the complex yet potentially transformative role of bilingualism in the lives of autistic individuals, offering a foundation for further exploration in the literature.

4.6. Limitations of the study and suggestions for overcoming them.

When discussing the limitations of a study, it is important to acknowledge the specific challenges that may have impacted the results. Here are some common limitations and suggestions for overcoming them in future research:

4.6.1. Sample Size and Diversity

Despite the pleasant large sample size of this meta-analysis, many studies on bilingualism and autism had limited participant characteristics. Consequently, there was no precise age calculated, but age ranges, the same can be said about the limited information on ethnicity and severity of autism. This restricts the generalisability of the findings. Future studies should aim more diverse samples that better represent the broad spectrum of the autistic community. In addition, studies that examine such cases should provide more detailed information on participants' characteristics in order to allow more meta-analysis on the topic.

4.6.2. Variables regarding bilingualism and participant status

Bilingualism is a complex variable, often simplified in studies. The degree of bilingualism (e.g., age of acquisition, proficiency in each language, frequency of use) can vary significantly among participants and affect cognitive outcomes. Unfortunately, despite the presence of such data in the studies included in the meta-analysis, such variables were not collected nor taken into account. It is therefore suggested that future research include these variables in their analysis, providing a more comprehensive evaluation of participants'

language history and proficiency levels to classify and understand the impact of different bilingual environments more accurately.

Furthermore, other important variables include socio-economic status, education level, or additional neurodevelopmental disorders. Most relevant studies provided said information, but once again this meta-analysis did not gather nor used these variables in its calculations. Implementing such variables should be a crucial part in the coding process in future research as it will provide more reliable results.

4.6.3. Proximity/Distality

As evident in Figure 3, only about 20% of included studies were of distality measure that tracked changes over time. Given the difficulties of finding participants in autism research and the risk of losing a participant throughout the testing process, it is no surprise that most studies focused on short term examinations and result generations. Nevertheless, the importance of long-term examinations is so vital that more longitudinal studies need to enrich autism literature. Said studies, if focused on the effects of bilingualism, could help determine how bilingualism impacts development across different life stages.

4.6.4. Parent/caregiver participation

This study, despite excluding reports based on the perceptions and opinions of parents and or caregivers, included data from parent reports. When the researchers gave specific reports / testing guidelines and renounced checklists, this study decided to include them in its meta-analysis. However, it is important to note that familiar subjects to the participants may favour the results willingly or not. Thus, a huge bias needs to be considered when looking at results including parent participation in the examination process. Future research should limit itself in the use of familiar faces to the participants, giving this task to a trained professional who will not only accurately gather the results, but also provide an unfamiliar environment to the participants.

5. Conclusion

This thesis has comprehensively examined the intersection of bilingualism and ASD, exploring how bilingualism affects autistic individuals across cognitive, linguistic, adaptive, and social communication domains. Motivated by both personal, professional, and demographic reasons, it hopes to provide useful insight on this complicated matter. Through a calculated methodological process, this study conducted a systematic review of the literature which was later analysed in depth and process for a meta-analysis.

The findings from this research indicate that bilingualism may provide positive impact on the cognitive abilities of autistic individuals, suggesting cognitive resilience possibly due to the demands of managing two languages. However, the effects on adaptive functioning, social communication, and linguistic outcomes resulted in small to null mean effect sizes, indicating that even though there may not be any bilingual advantage, bilingualism doesn't negatively impact autistic individuals in these domains. Interestingly, ASDM groups performed significantly lower than TDB and TDM for both cognitive and linguistic domains. The latter suggesting a small diagnostic effect. Furthermore, in all cases, ASDBH performed largely better than their ASDBL counterparts in all outcomes except the cognitive domain, which didn't gather any data from these populations. For both the social-communication and linguistic outcomes, ASDBSIM outperformed both ASDBSEQ and ASDM, further proving the effectiveness of simultaneous bilingualism and bilingualism itself for ASD individuals.

In conclusion, this thesis not only fills a critical gap in existing research but also lays a foundation for future studies to further investigate and clarify the role of bilingualism in the development of autistic individuals. Recommendations for future research include longitudinal studies that track the long-term impacts of bilingualism and more thoroughly conducted analyses that consider varying degrees of bilingualism and autism severity. Ultimately, the insights gained from this research seek to better inform those concerned on the matter of bilingualism in autism, as well as raise its awareness in our rapidly evolving multilingual society.

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Appendix

Figure 1
PRISMA 2020 flow diagram empty

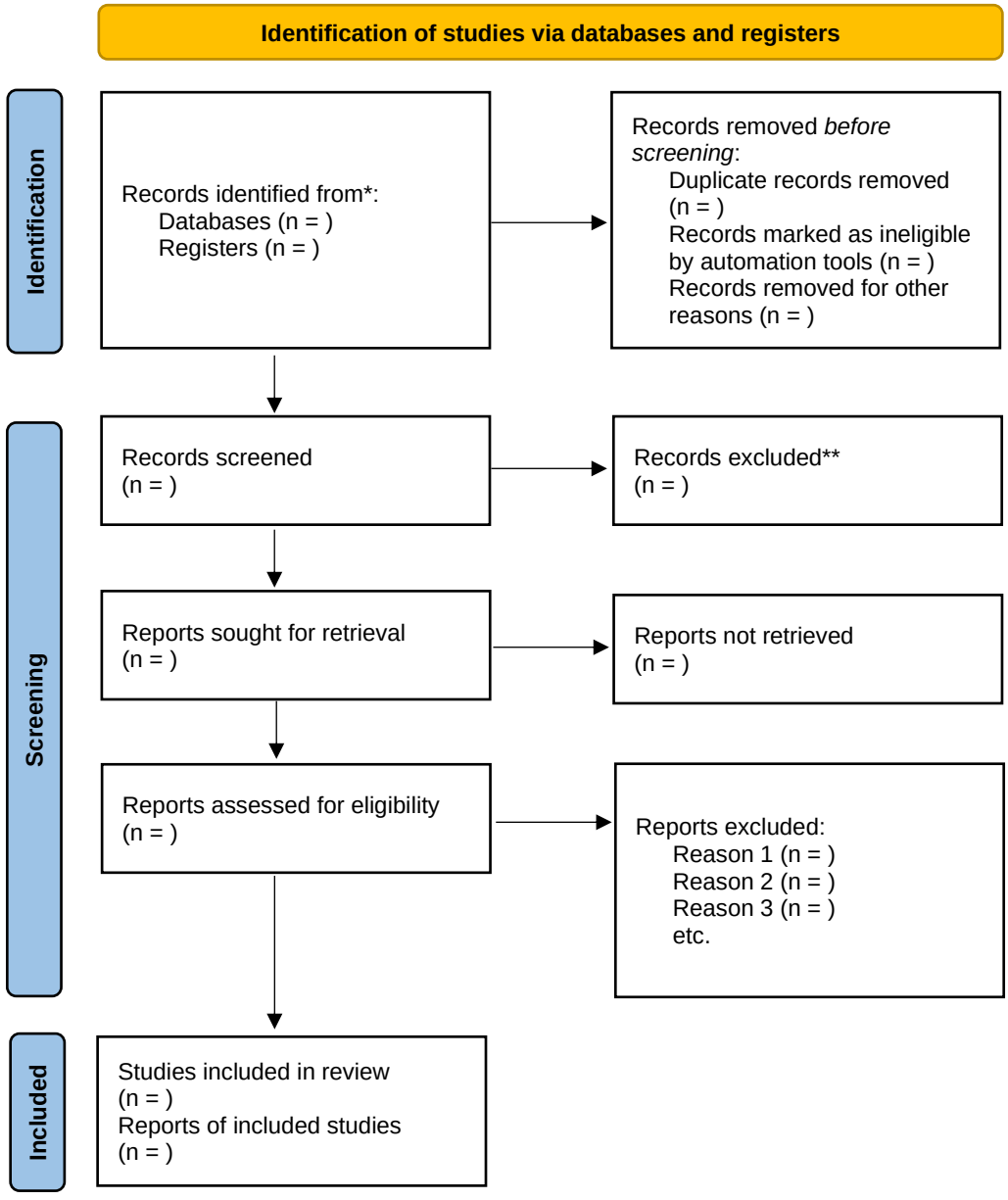


Figure 2 *ASReview efficiency*

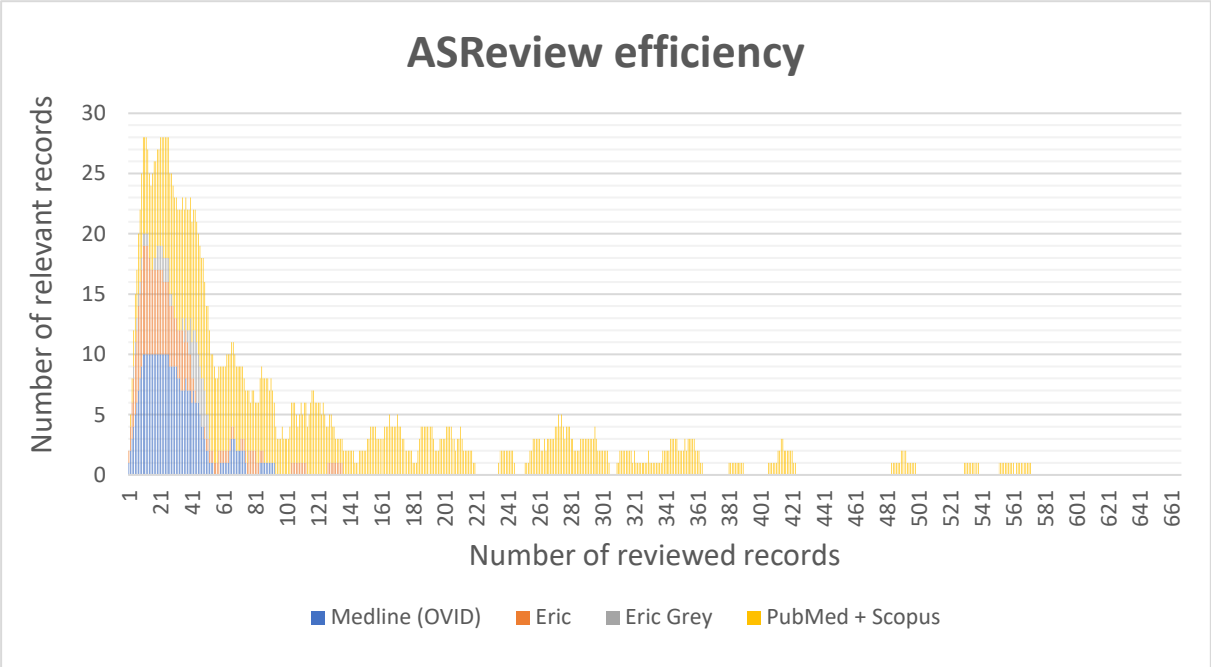


Figure 3
PRISMA 2020 flow diagram filled

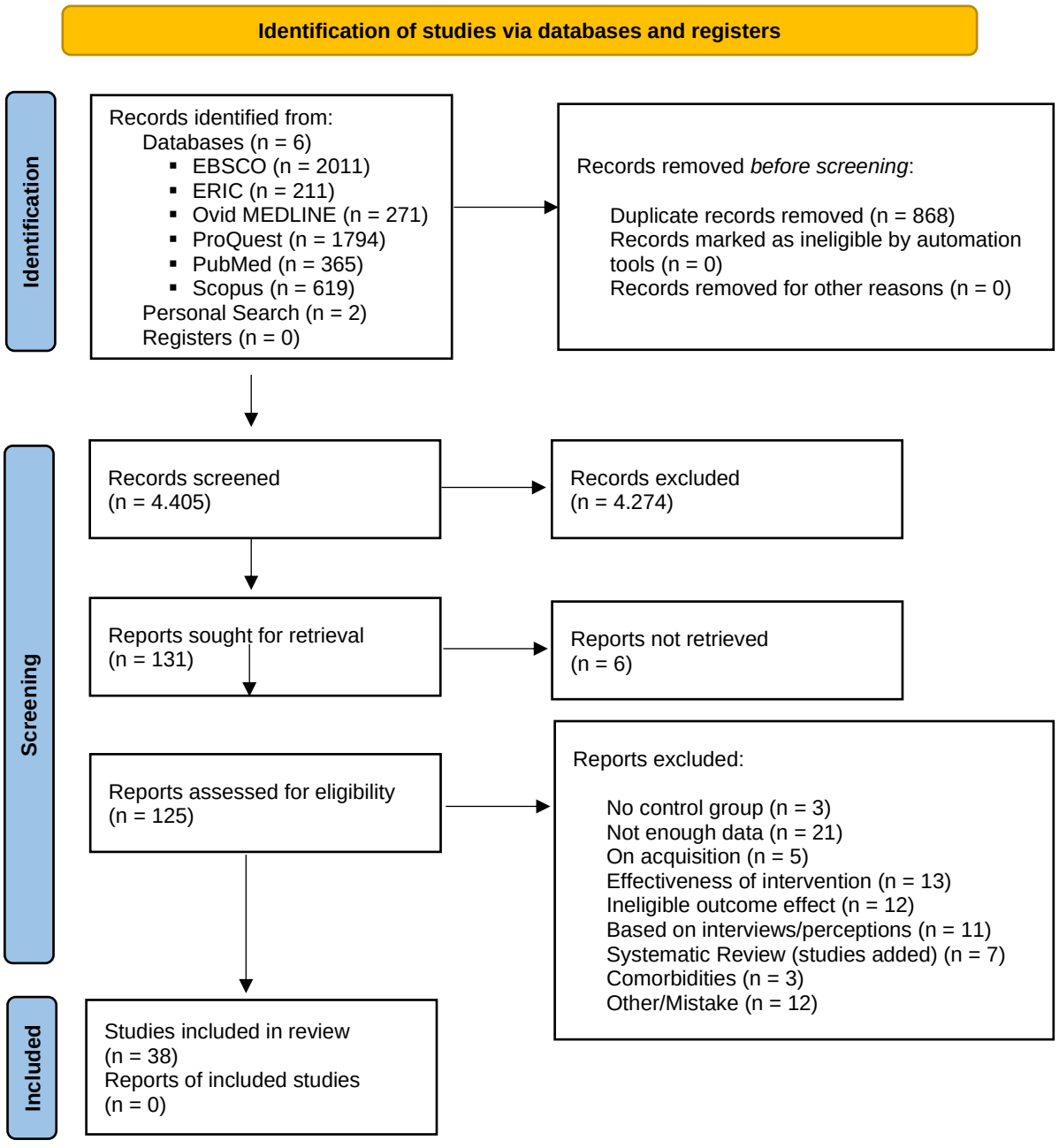


Figure 4 *Detection Bias for all Included Studies*

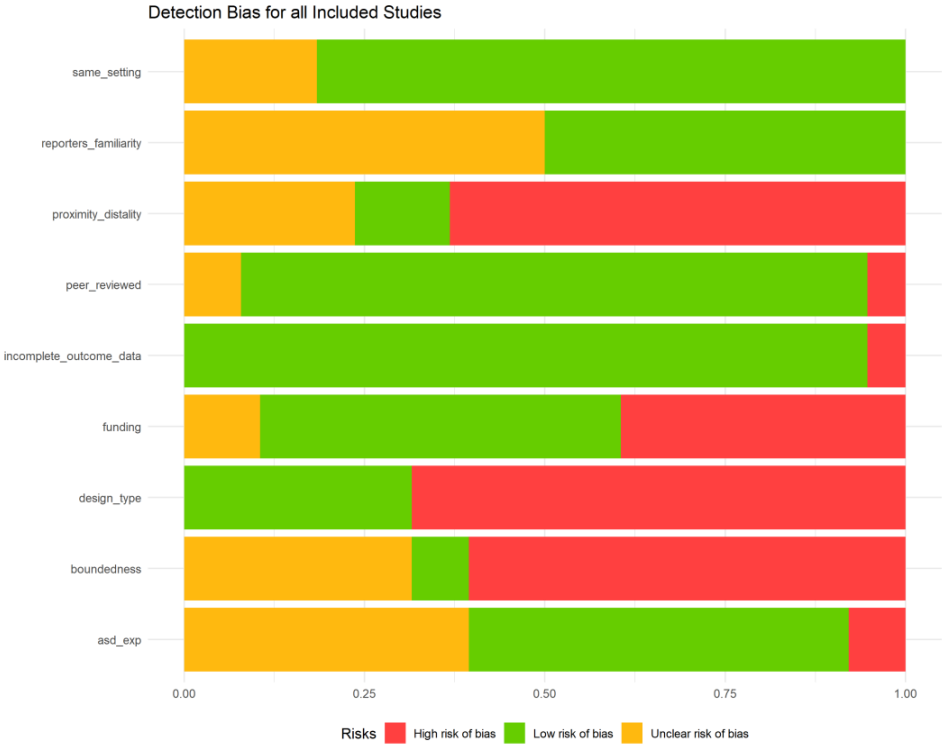


Figure 5 *Forest Plot of ASDB compared to ASDM Effect Sizes*

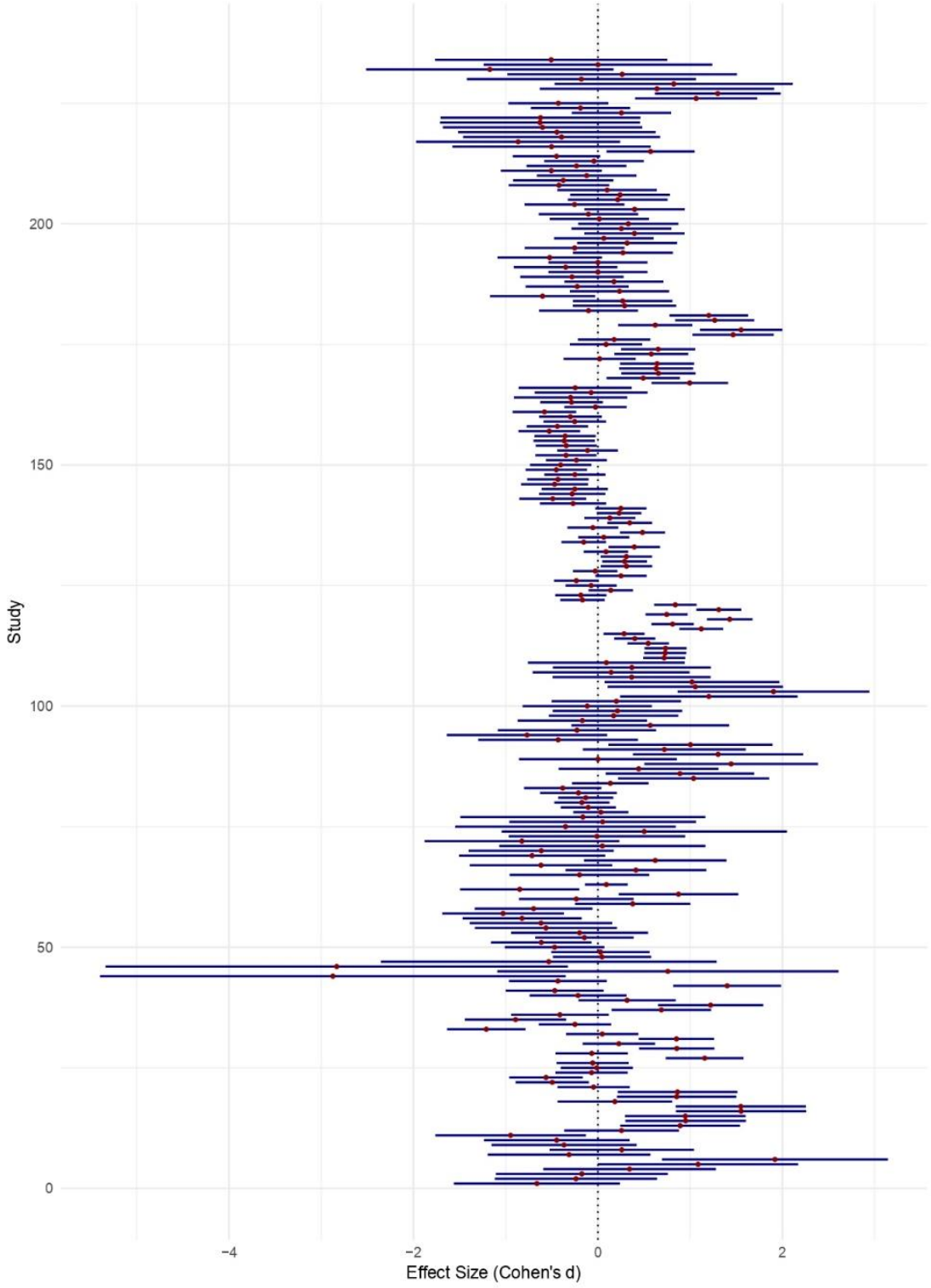


Figure 6 *Forest Plot of ASDB compared to TDB Effect Sizes*

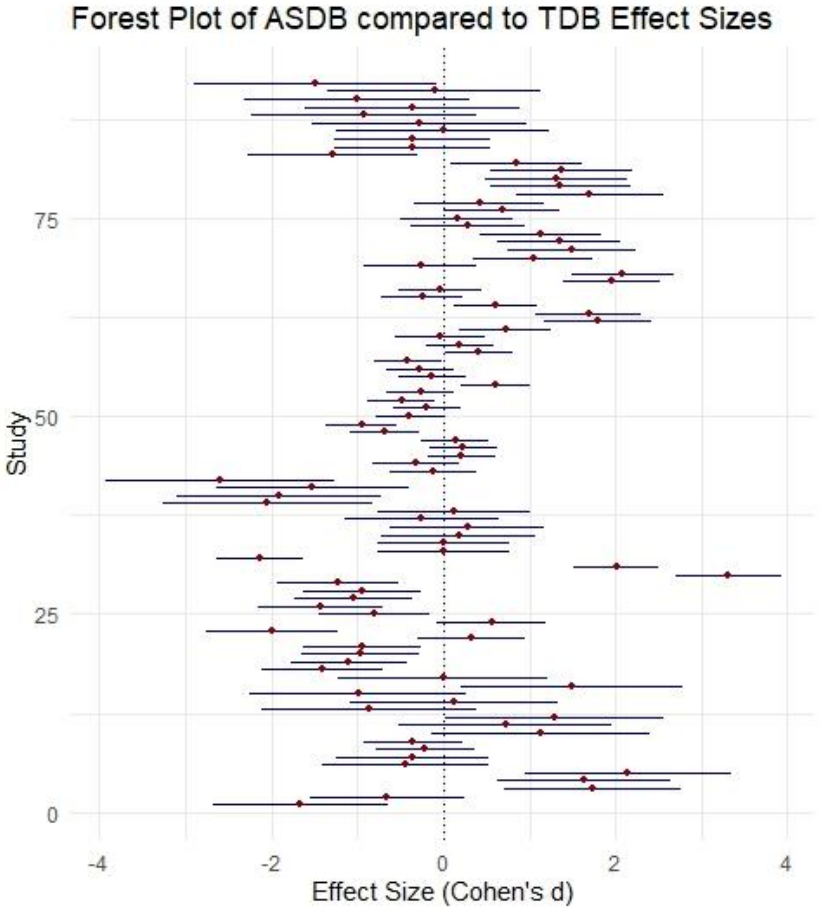


Figure 7 *Cognitive effects of bilingualism (ASDB – ASDM)*

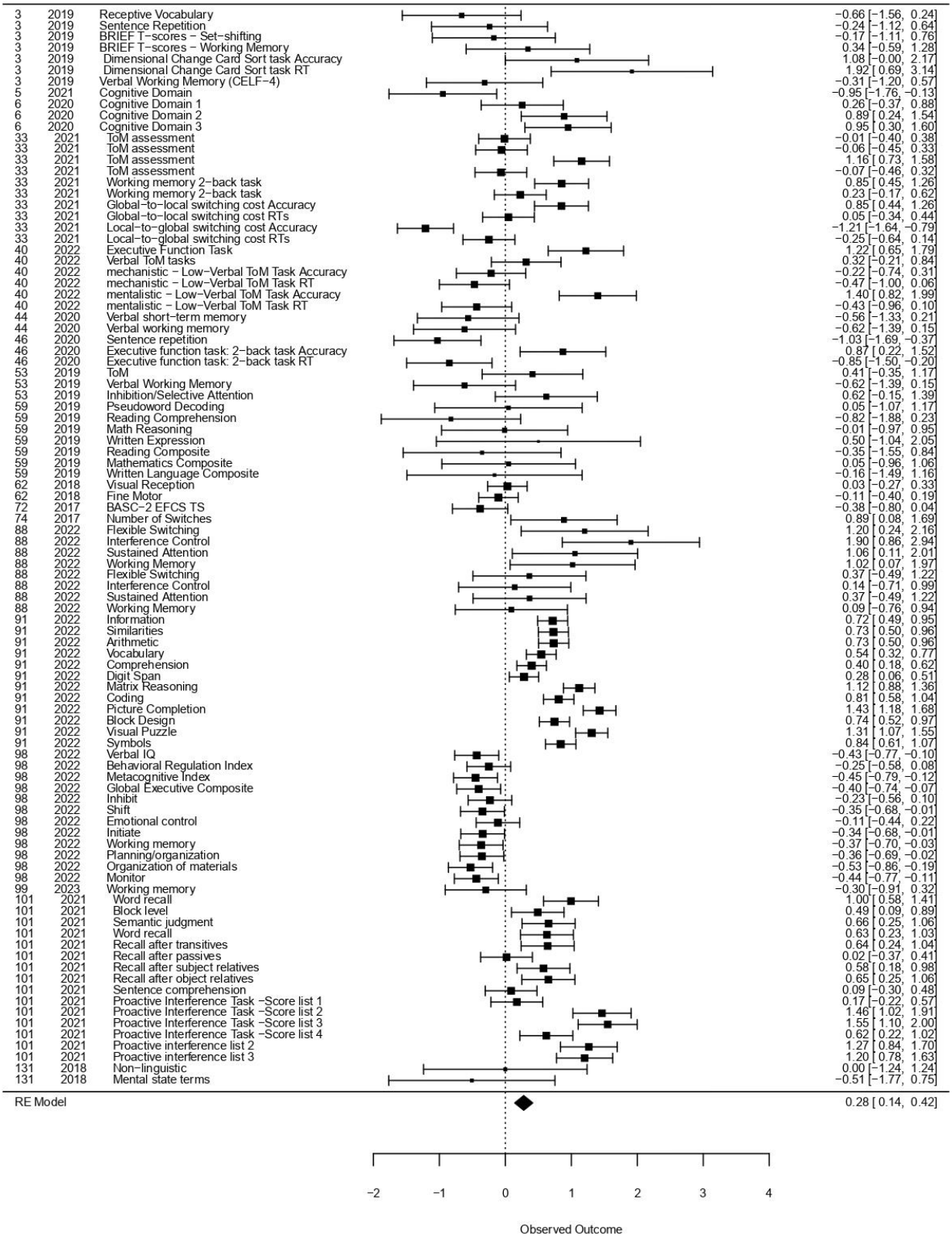


Figure 8 *Cognitive effects of bilingualism (ASDB – TDB)*

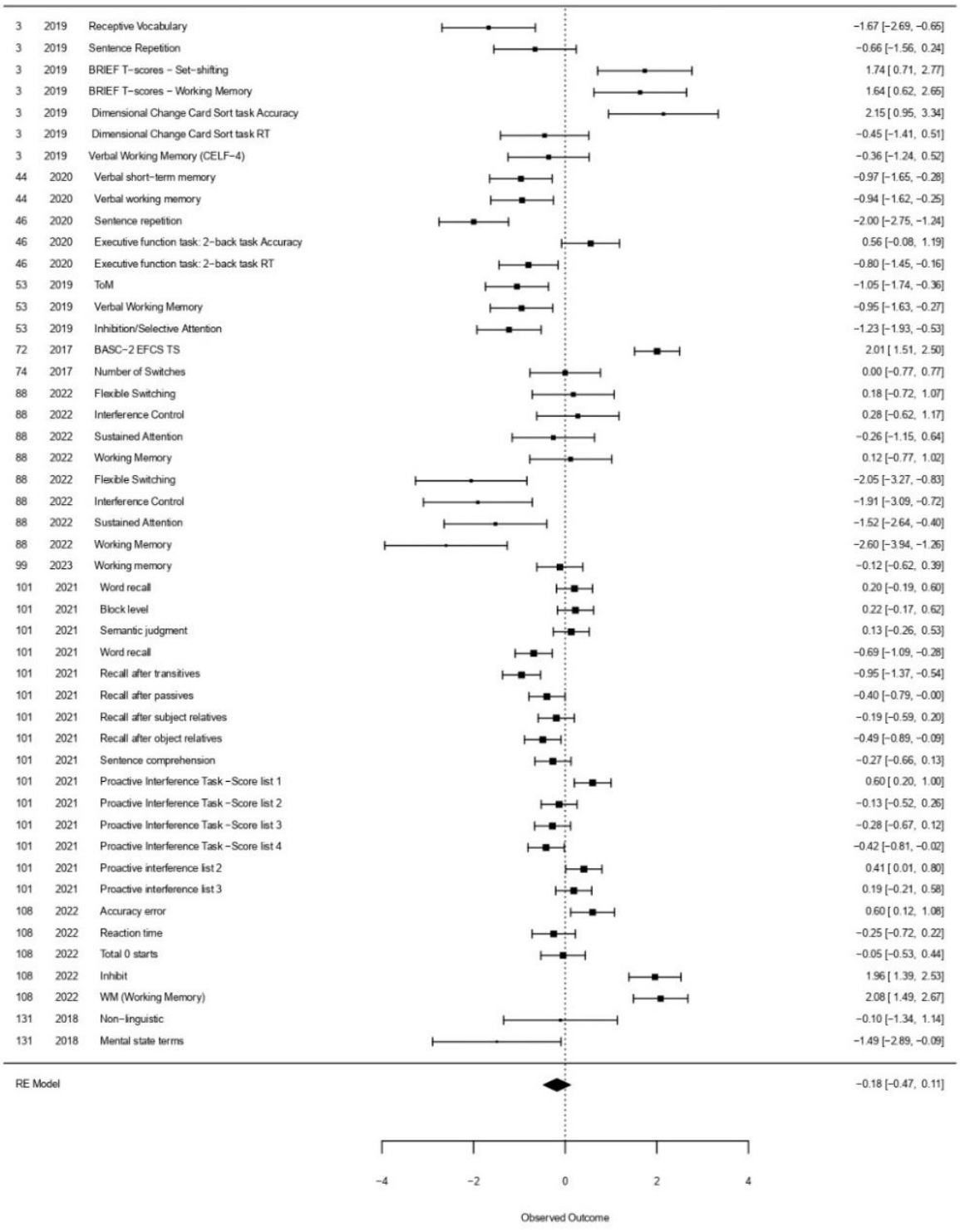


Figure 9 *Cognitive performance (ASDM – TDM)*

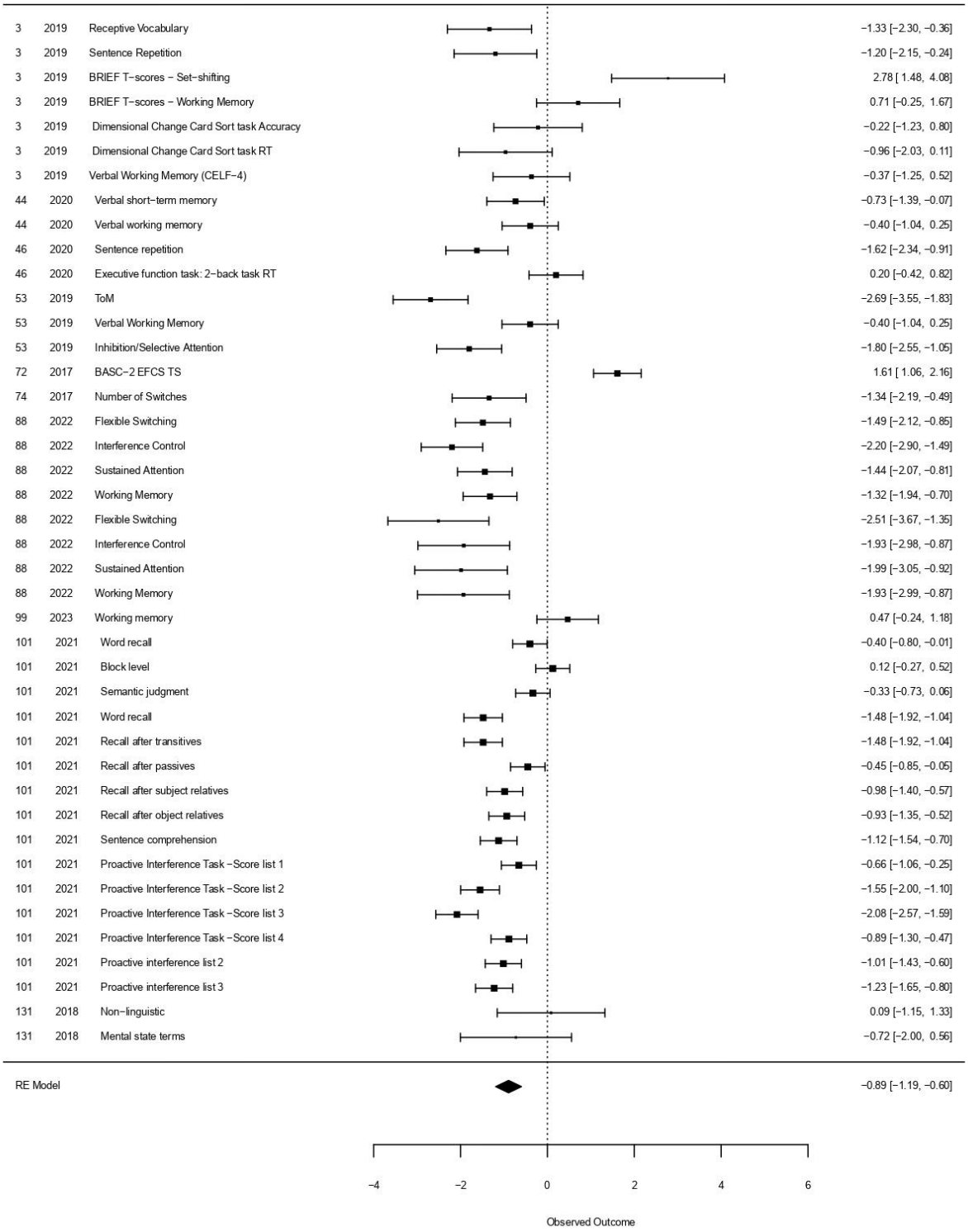


Figure 10 *Cognitive performance (ASDM – TDB)*

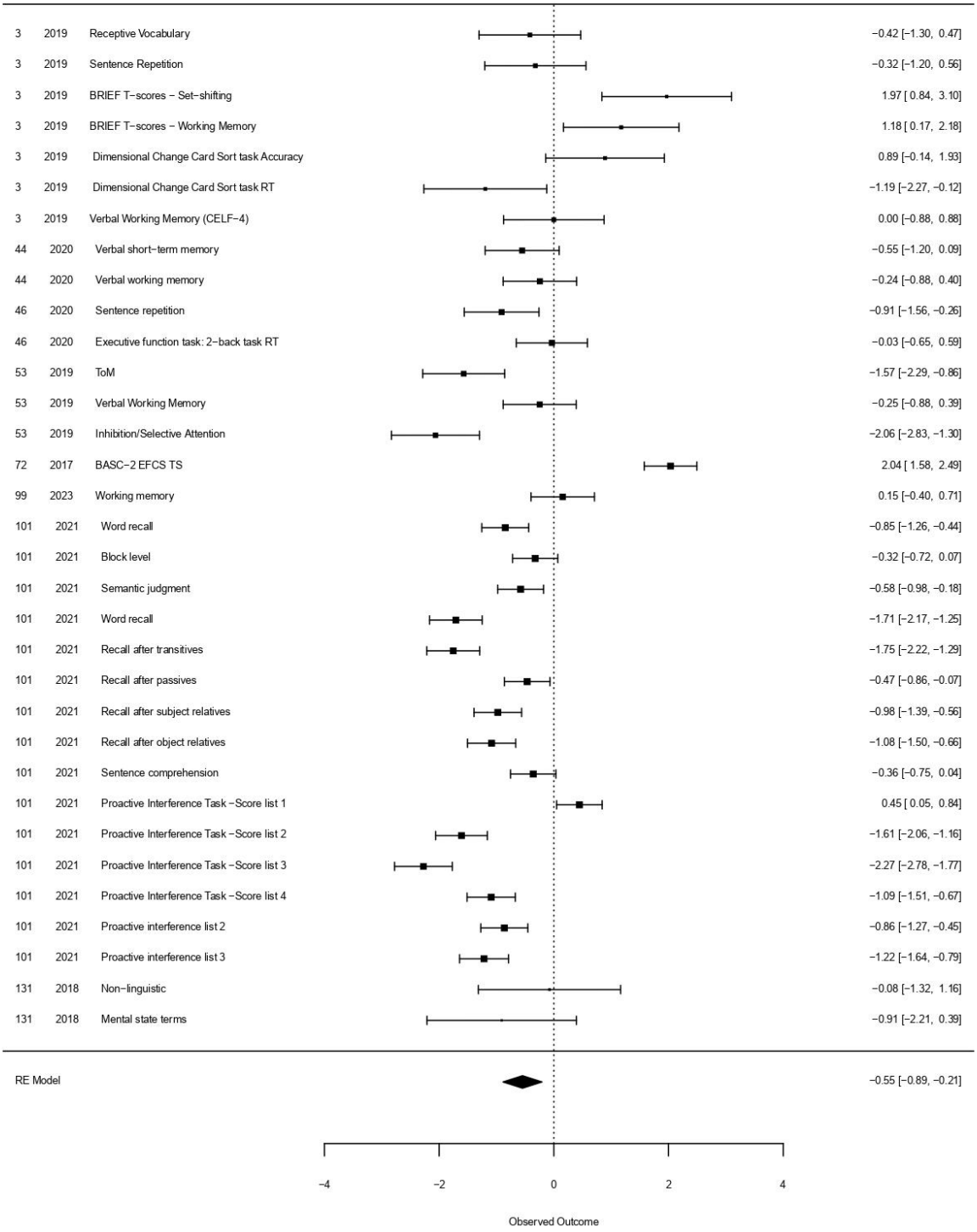


Figure 11 *Adaptive functioning effects of bilingualism (ASDB – ASDM)*

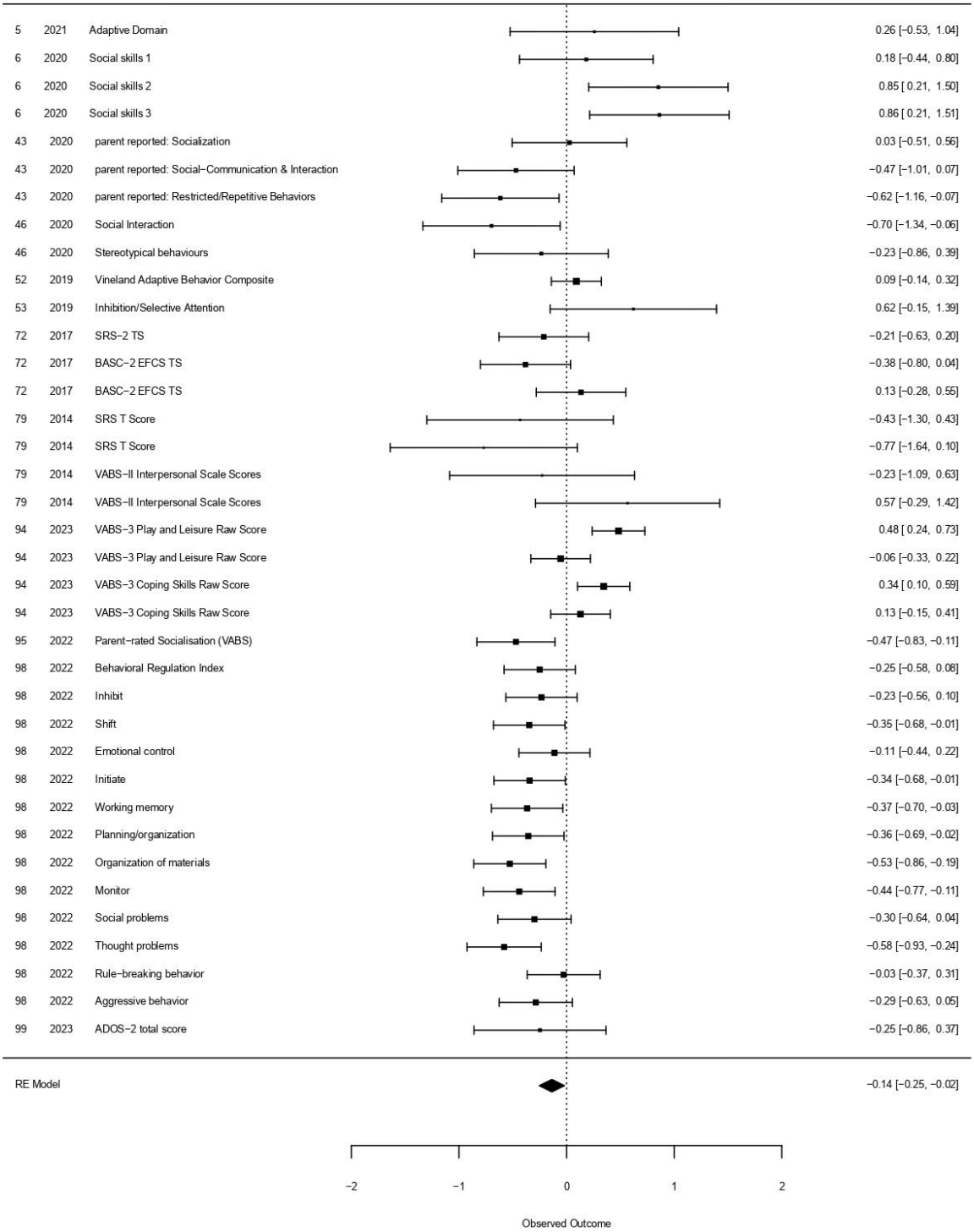


Figure 12 *Adaptive functioning performance (ASDB – TDB)*

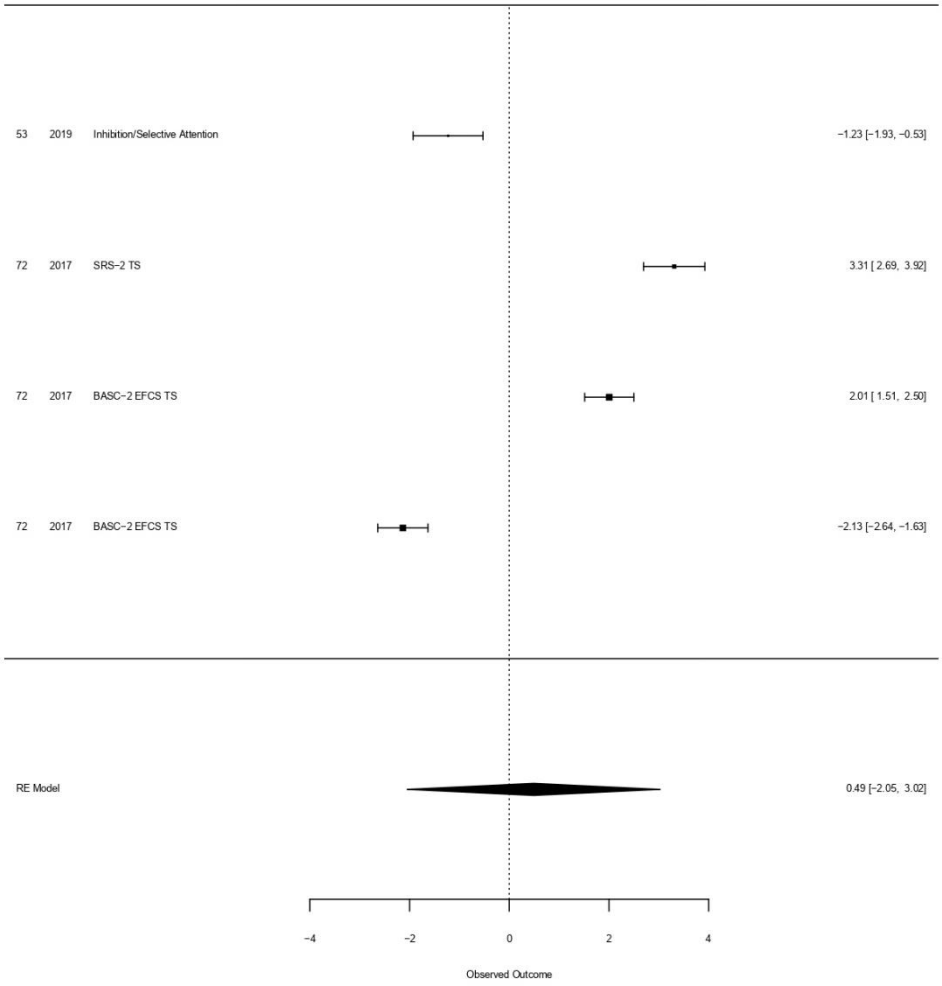


Figure 13 *Adaptive functioning performance (ASDBH - ASDM)*

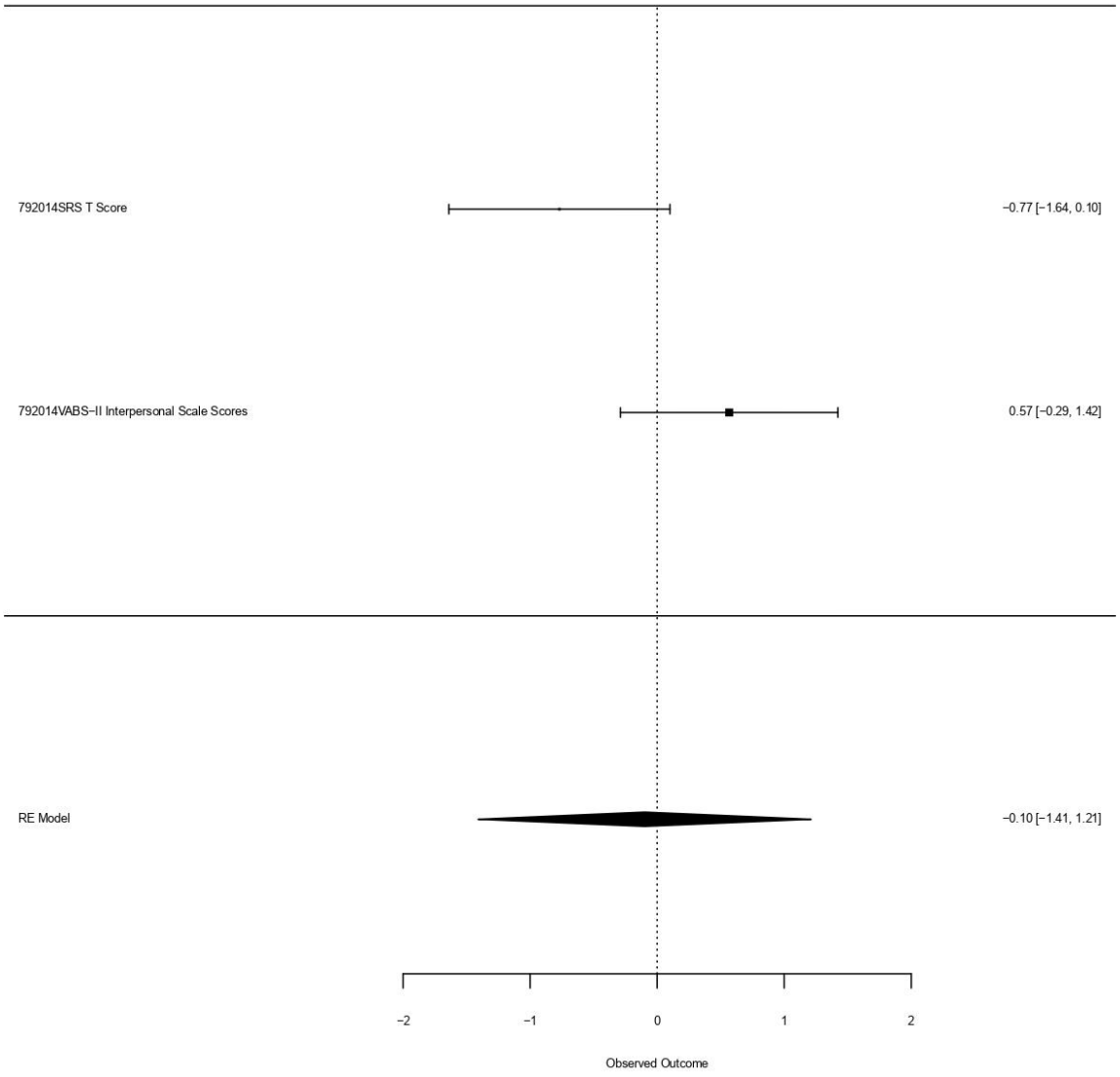


Figure 14 Adaptive functioning performance (ASDBL - ASDM)

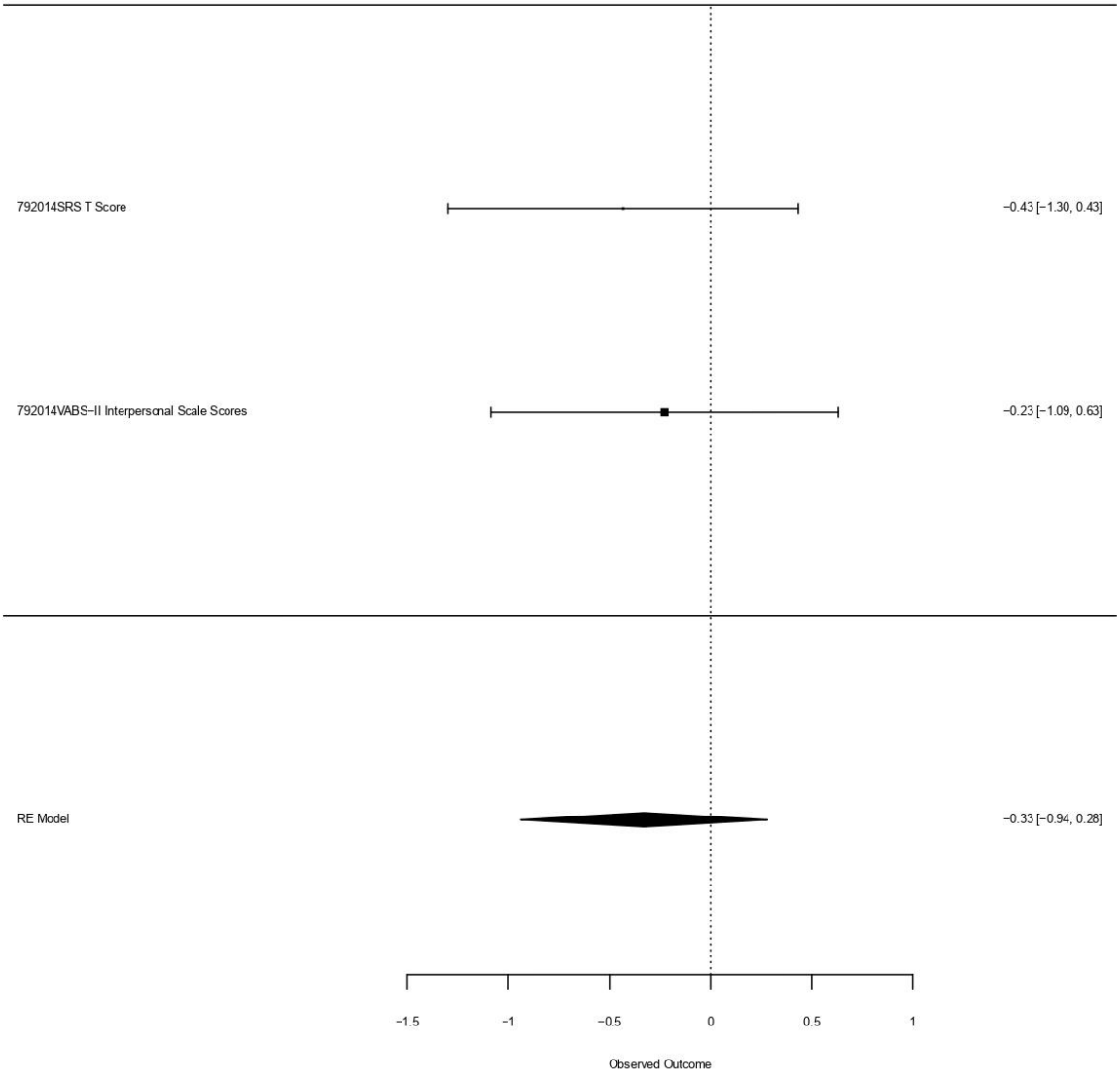


Figure 15 Adaptive functioning performance (ASDM – TDB)

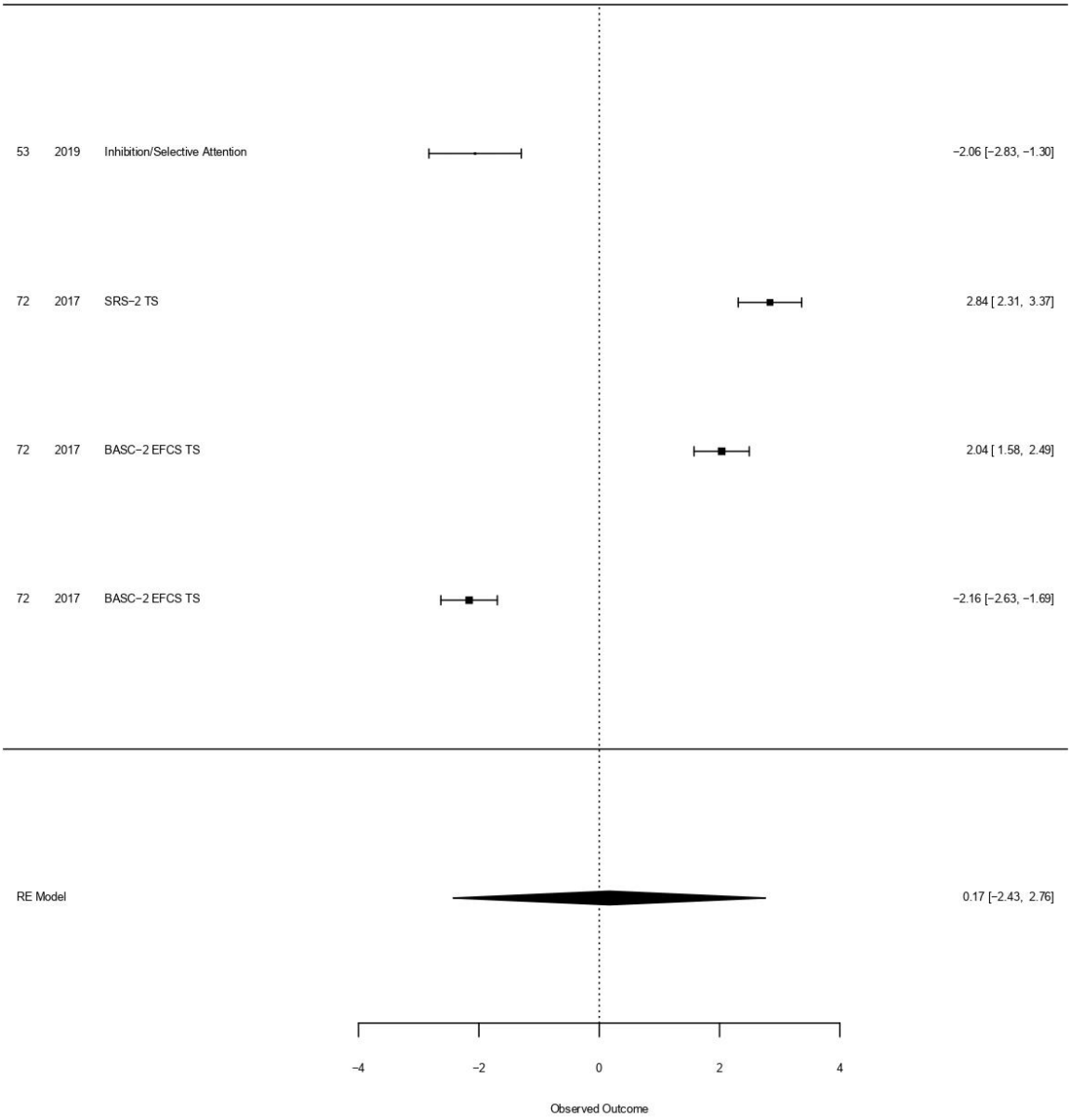


Figure 16 *Adaptive functioning performance (ASDM – TDM)*

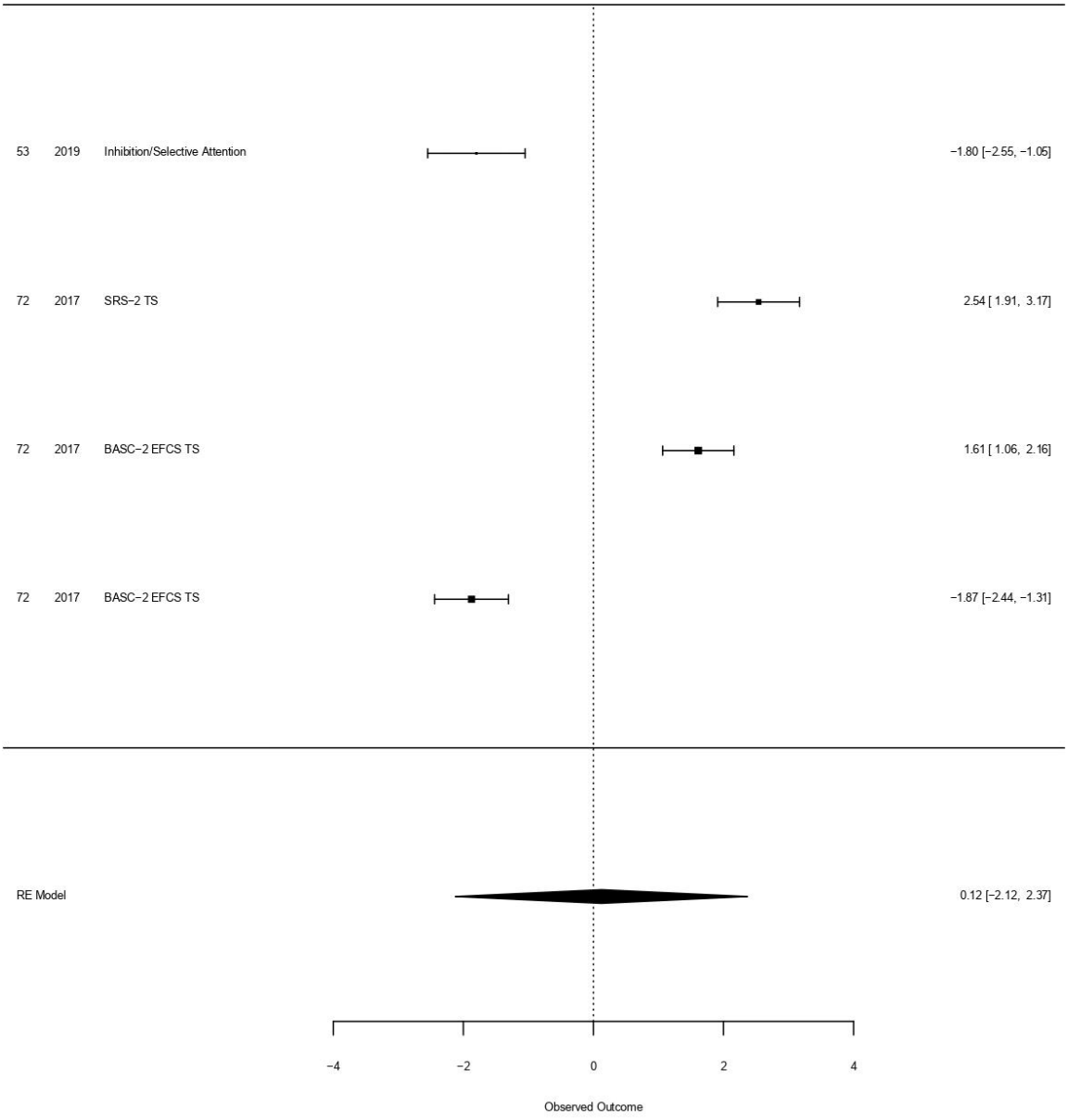


Figure 17 *Social-Communication performance (ASDB – ASDM)*

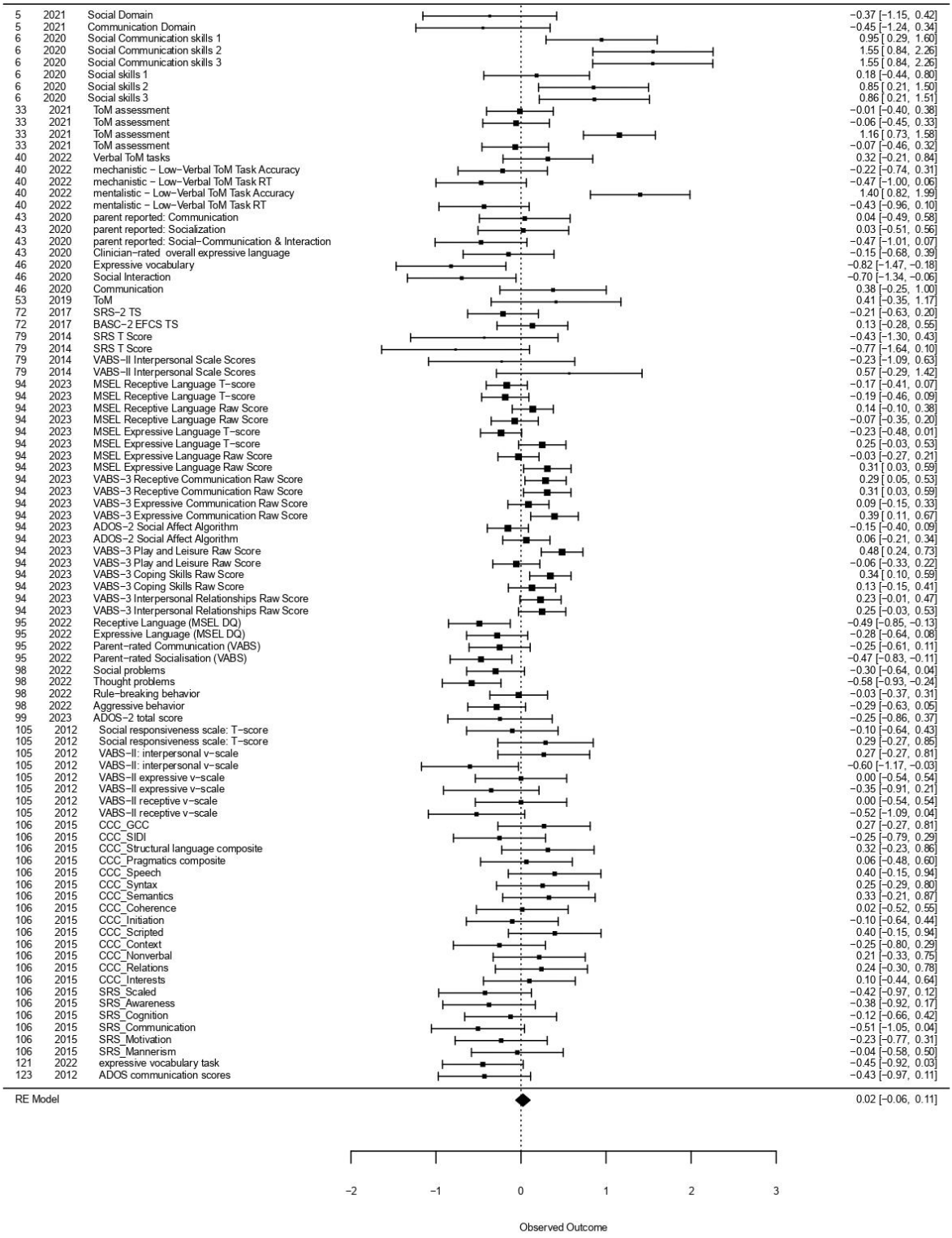


Figure 18 *Social-Communication performance (ASDB – TDB)*

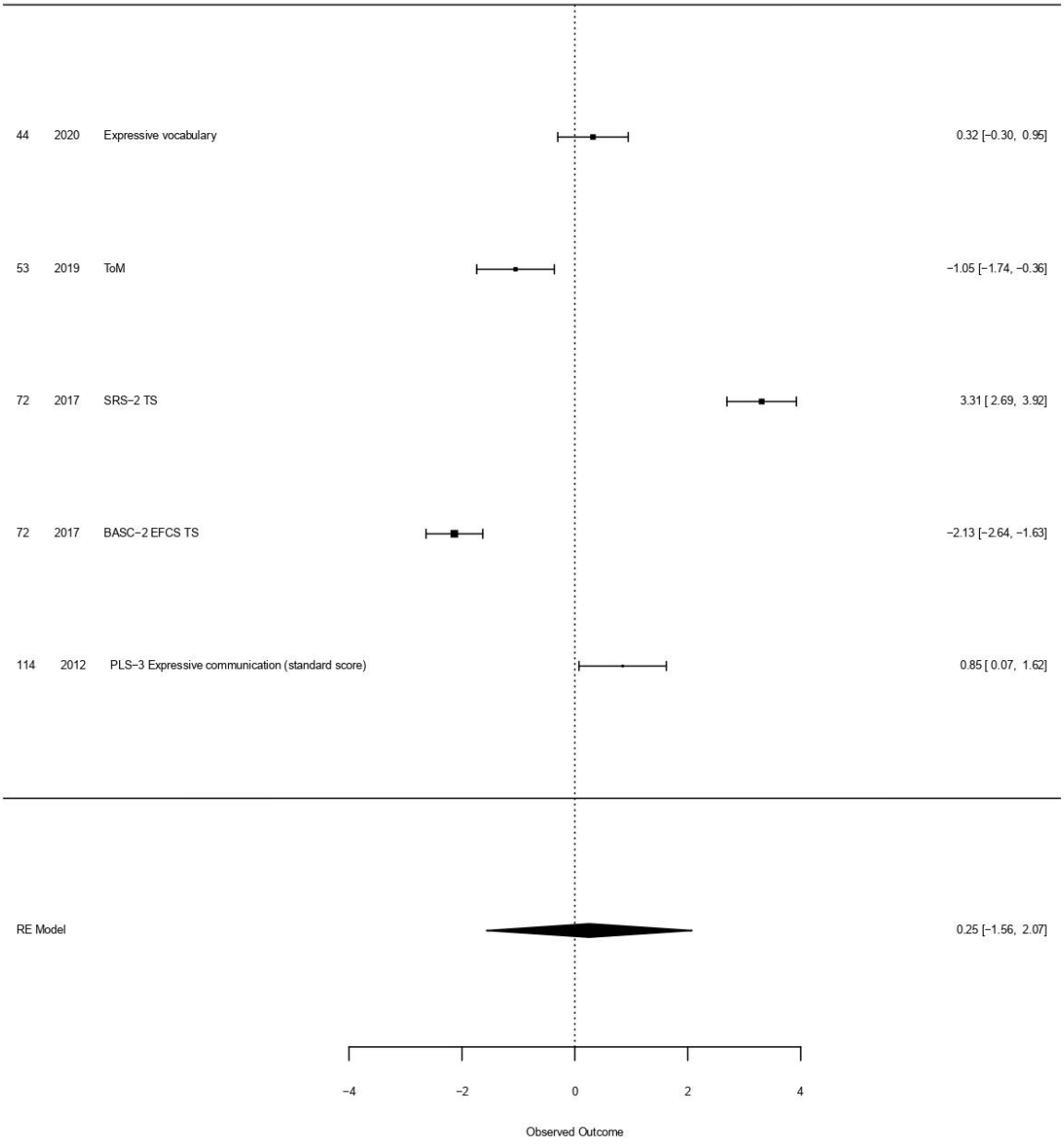


Figure 19 *Social-Communication performance (ASDBH – ASDM)*

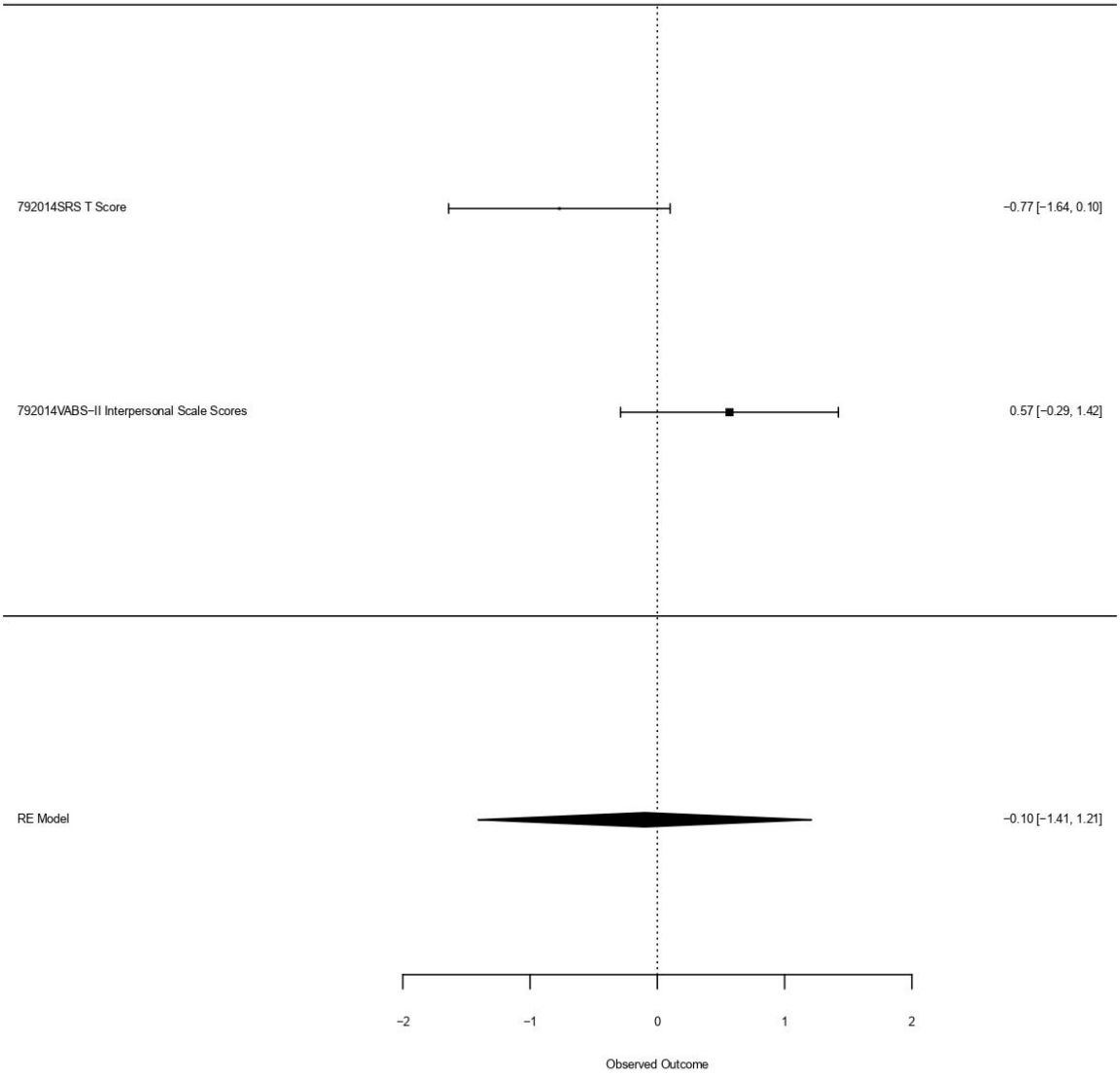


Figure 20 *Social-Communication performance (ASDBL – ASDM)*

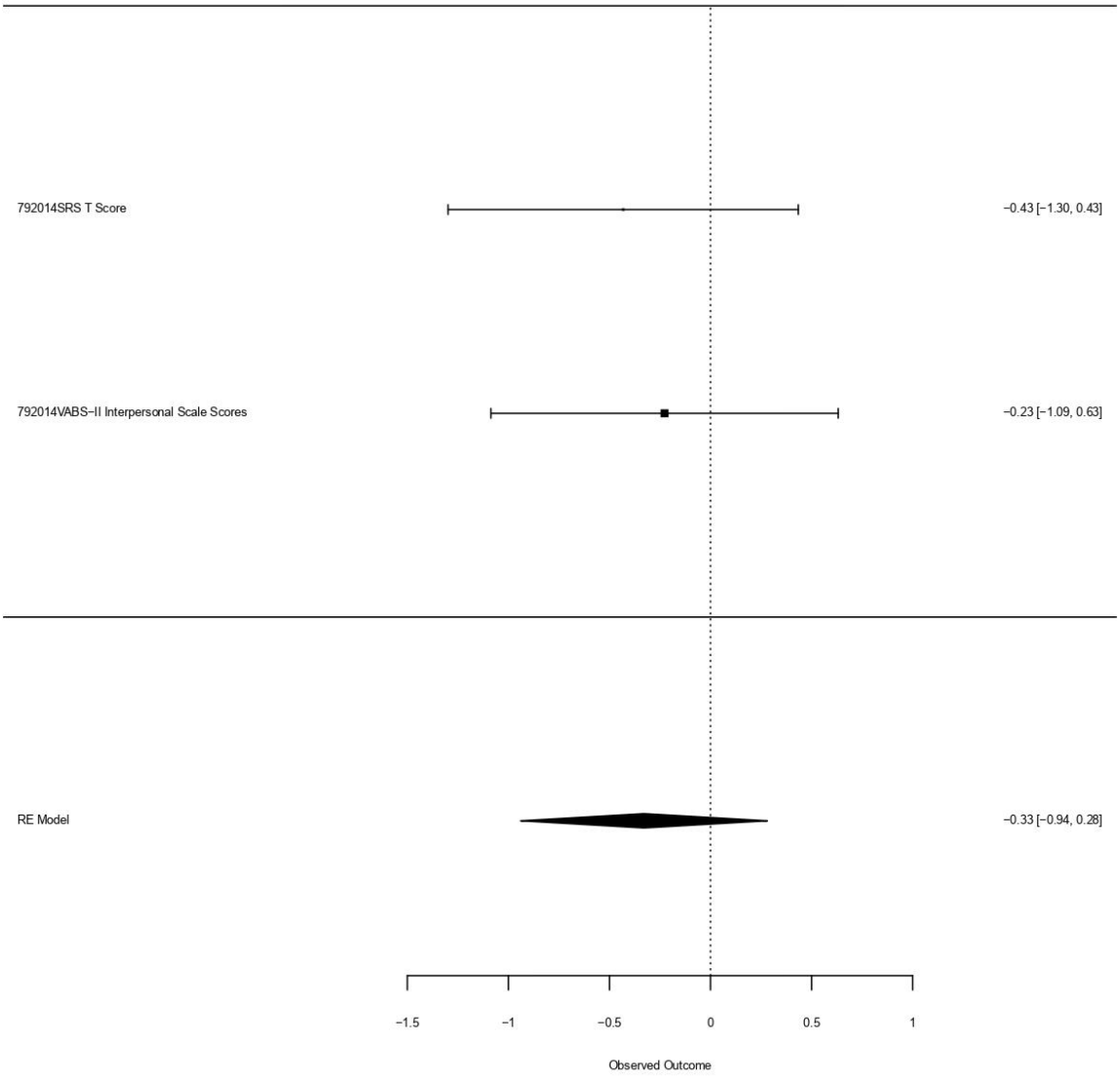


Figure 21 *Social-Communication performance (ASDBSEQ – ASDM)*

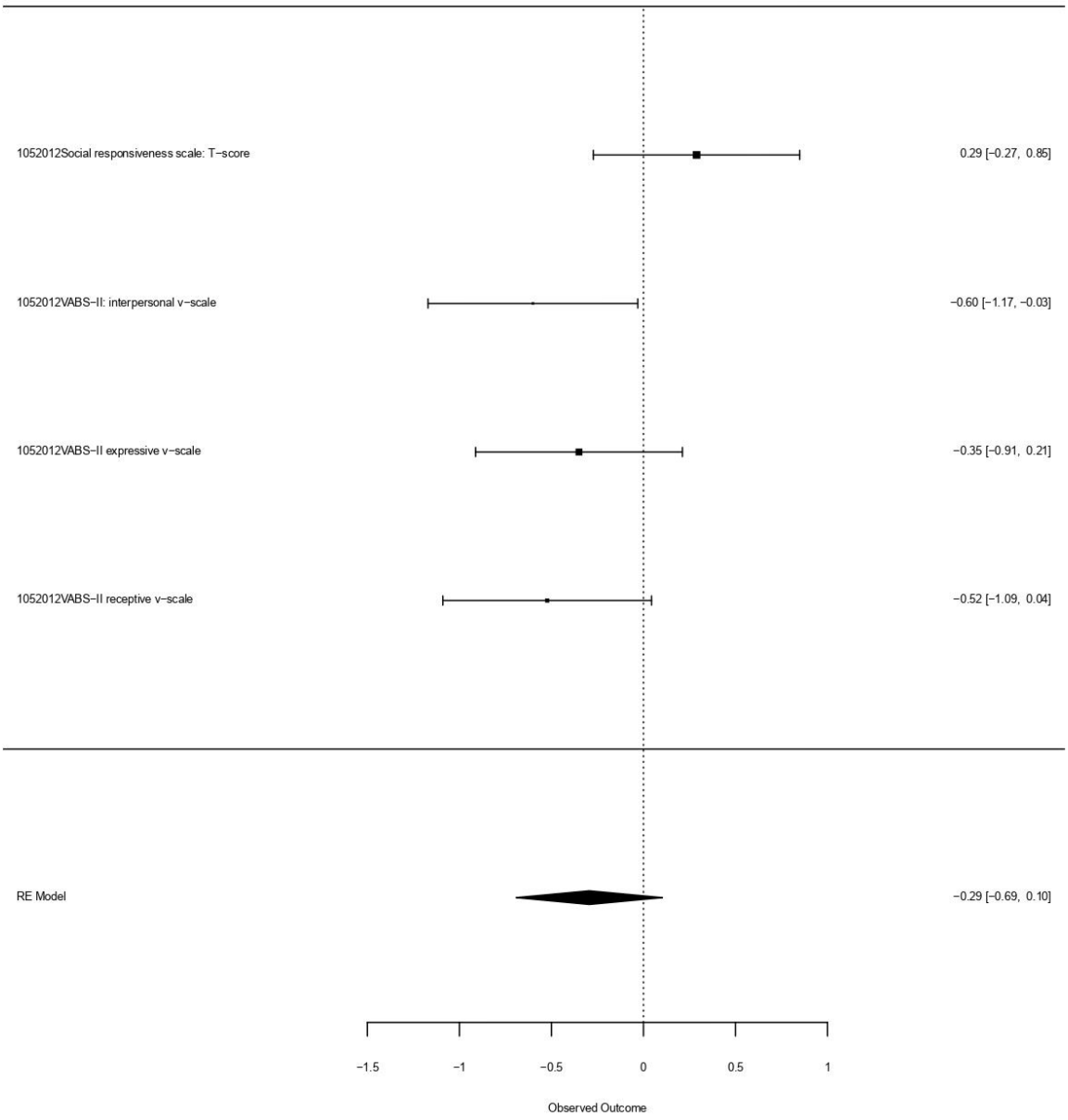


Figure 22 *Social-Communication performance (ASDBSIM – ASDM)*

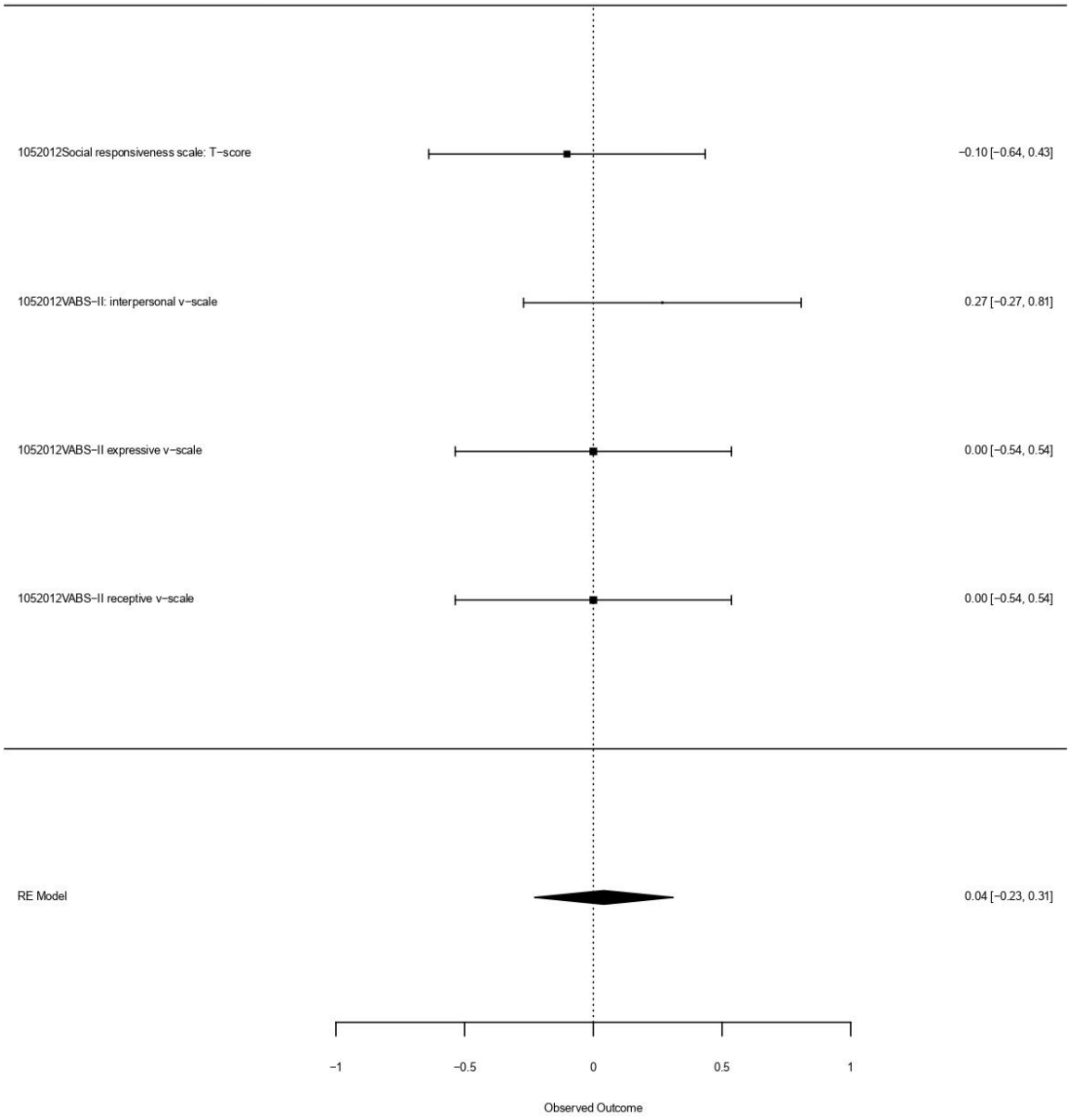


Figure 23 Social-Communication performance (ASDM – TDB)

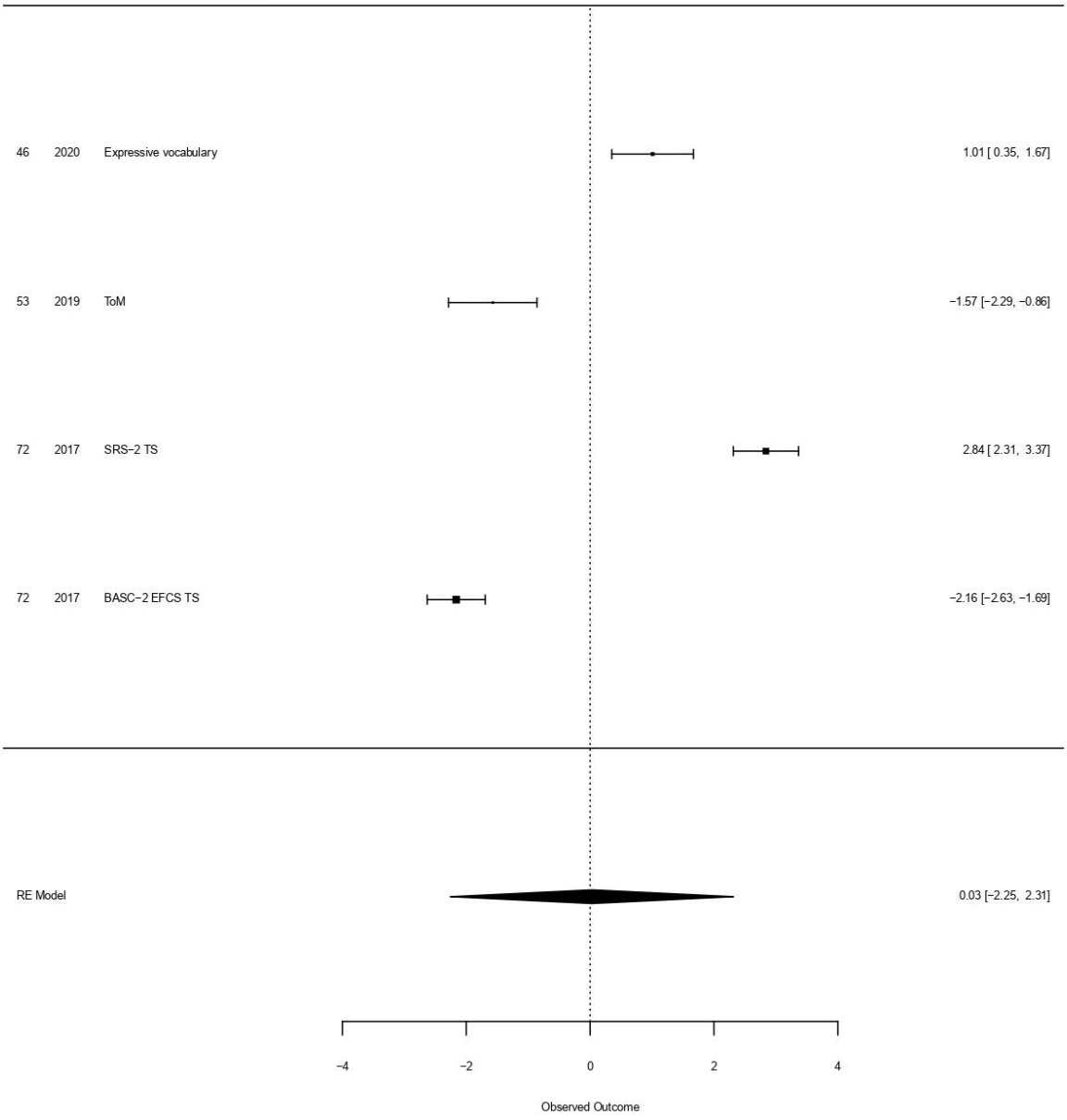


Figure 24 *Social-Communication performance (ASDM – TDM)*

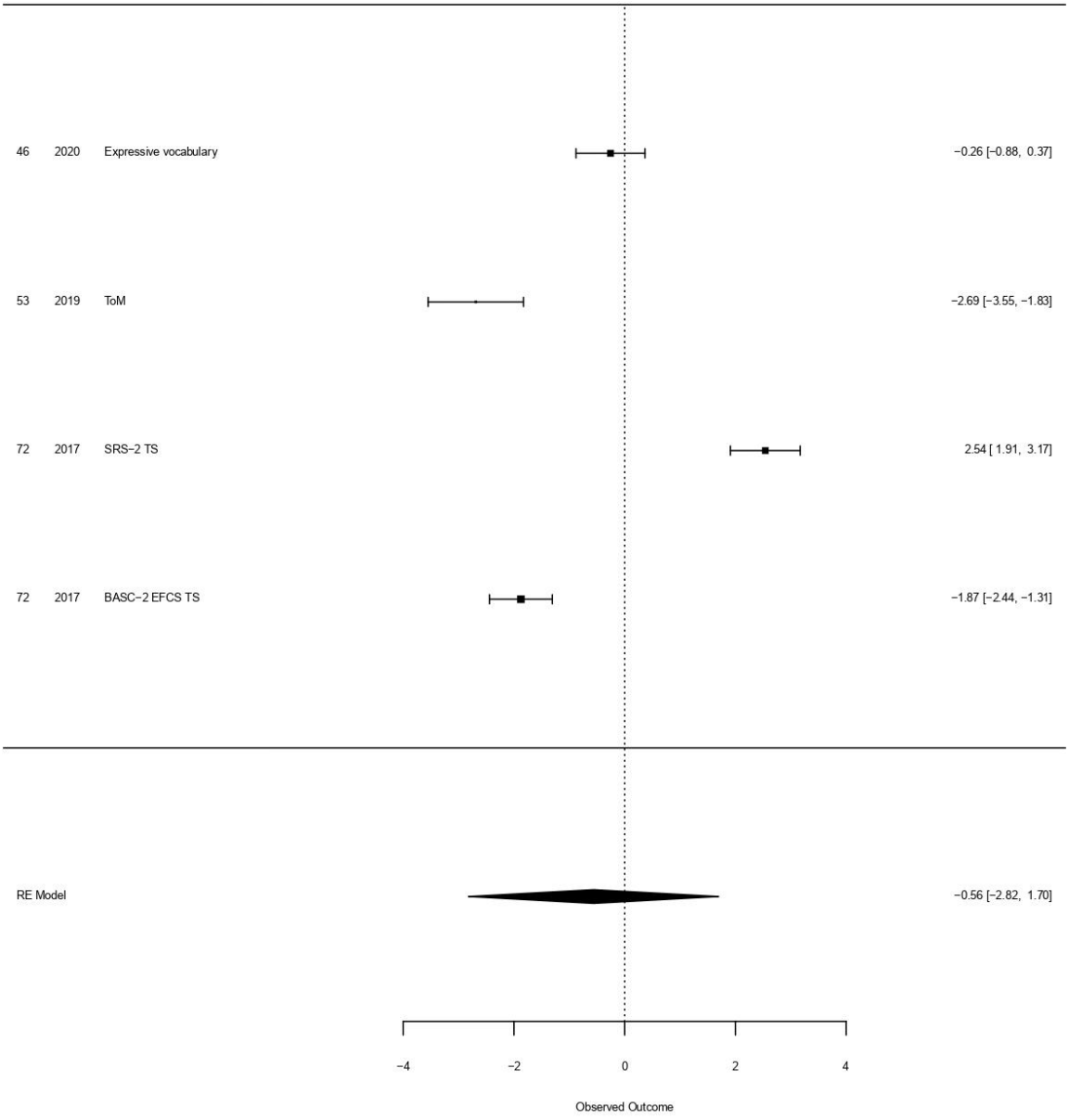


Figure 25 *Linguistic performance (ASDB – ASDM)*

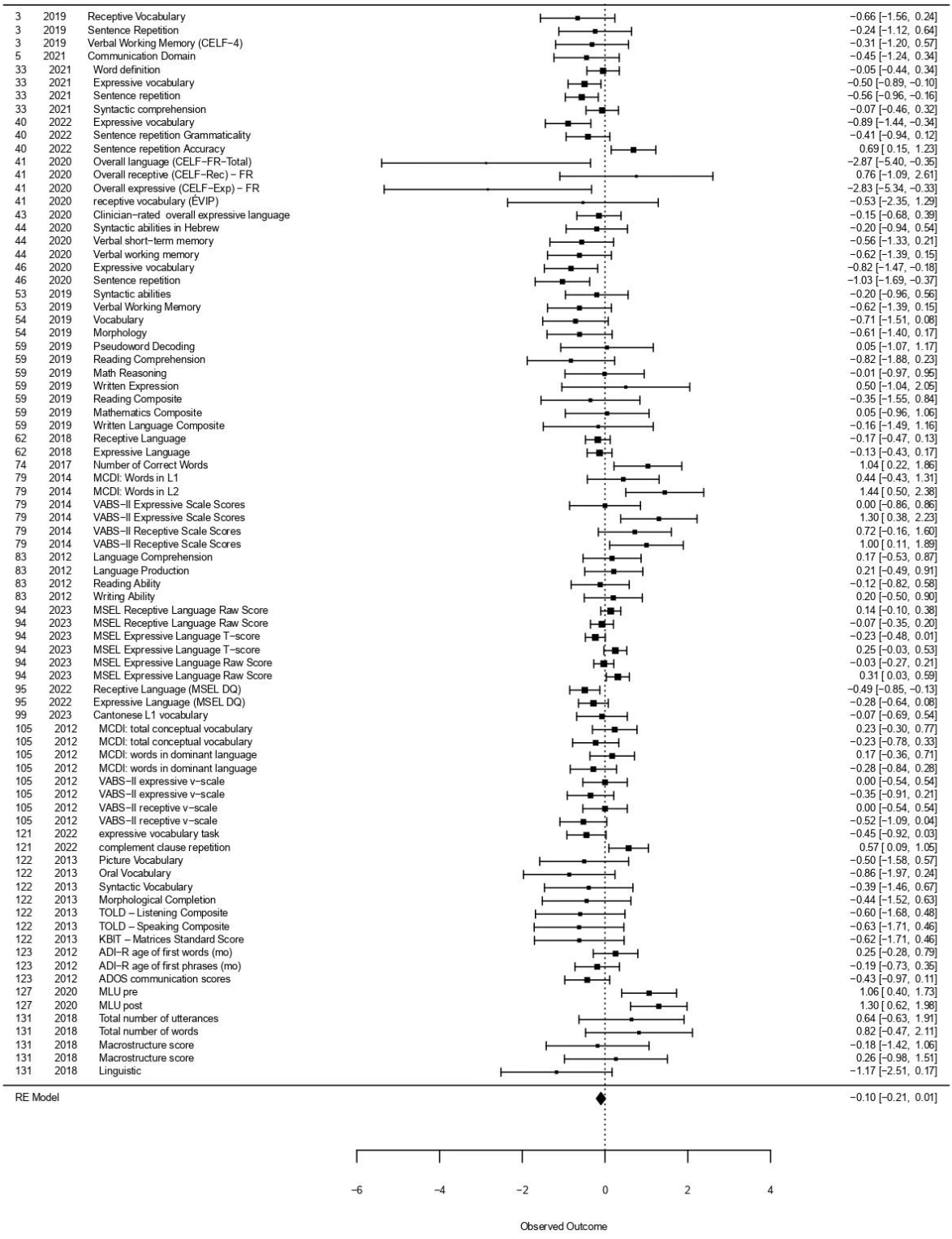


Figure 26 *Linguistic performance (ASDB – TDB)*

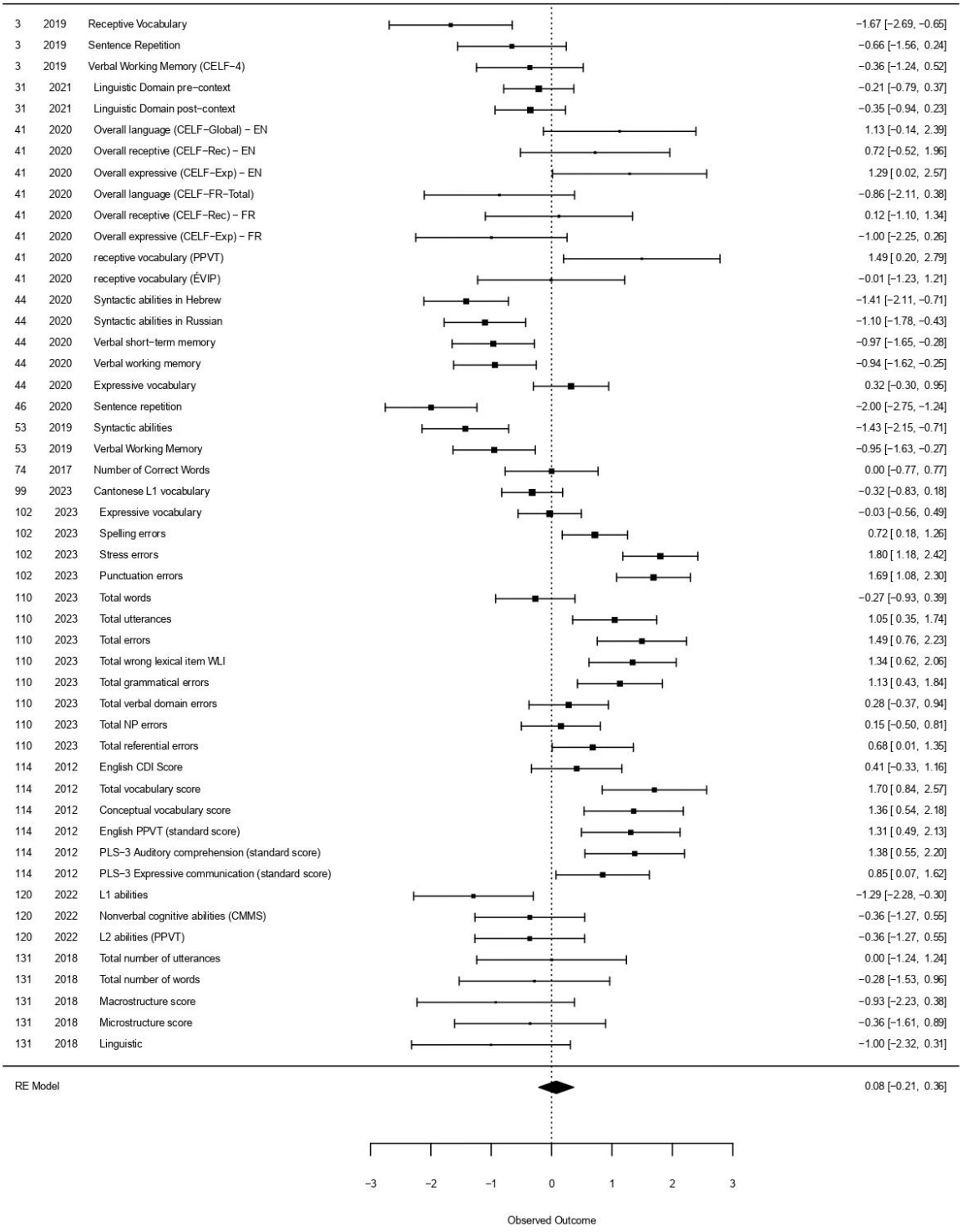


Figure 27 *Linguistic performance (ASDBH – ASDM)*

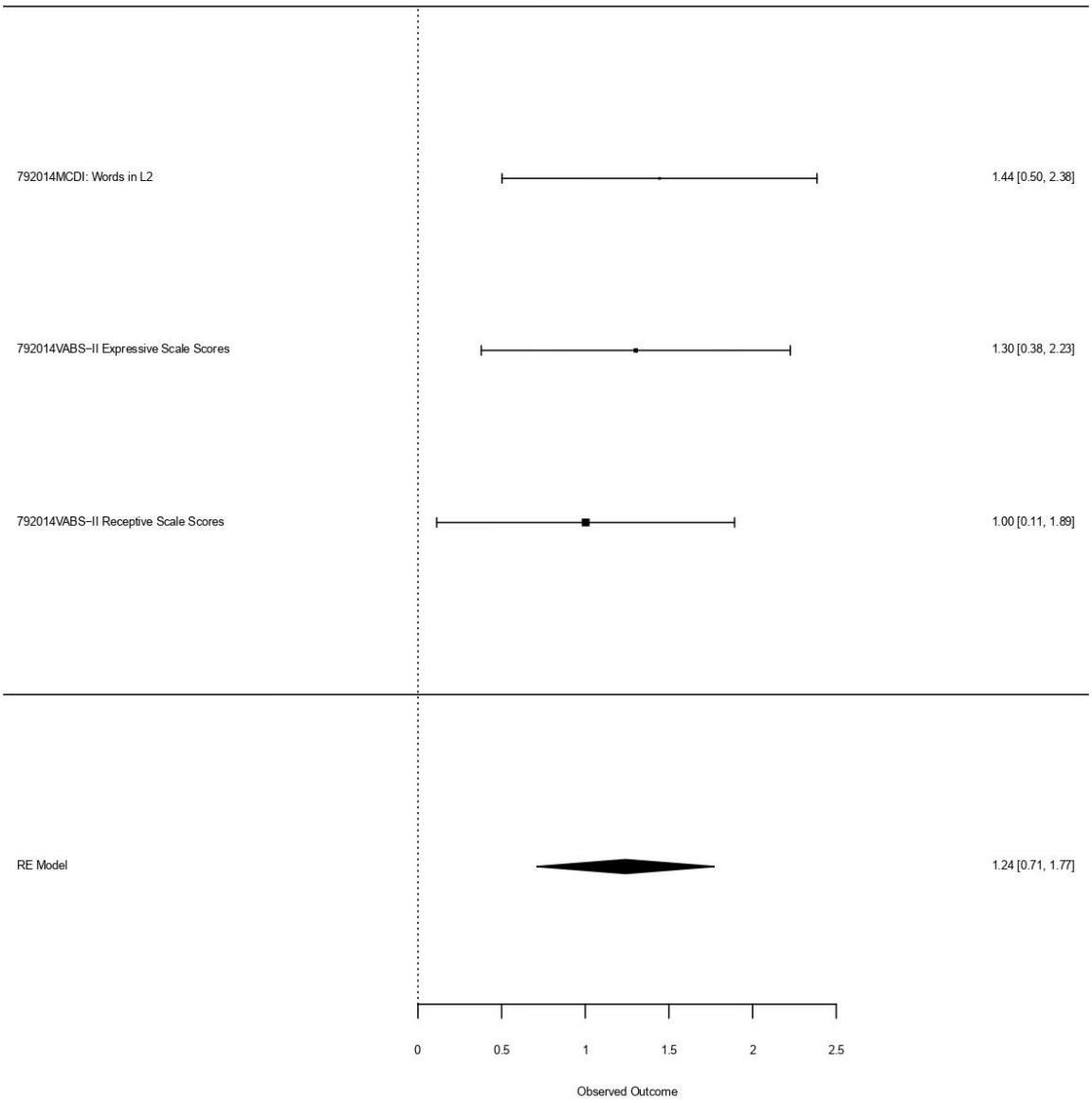
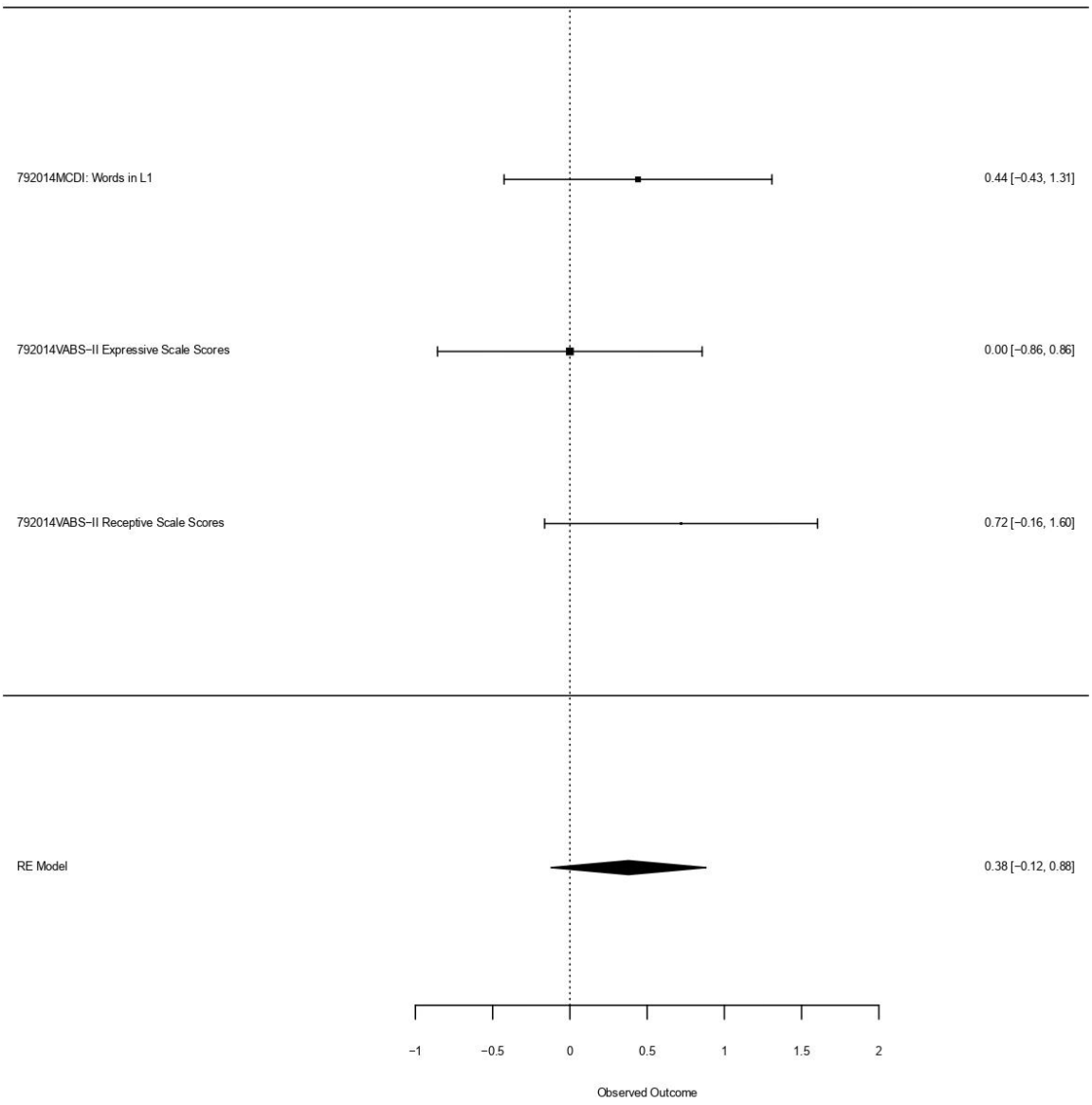


Figure 28 *Linguistic performance (ASDBL – ASDM)*



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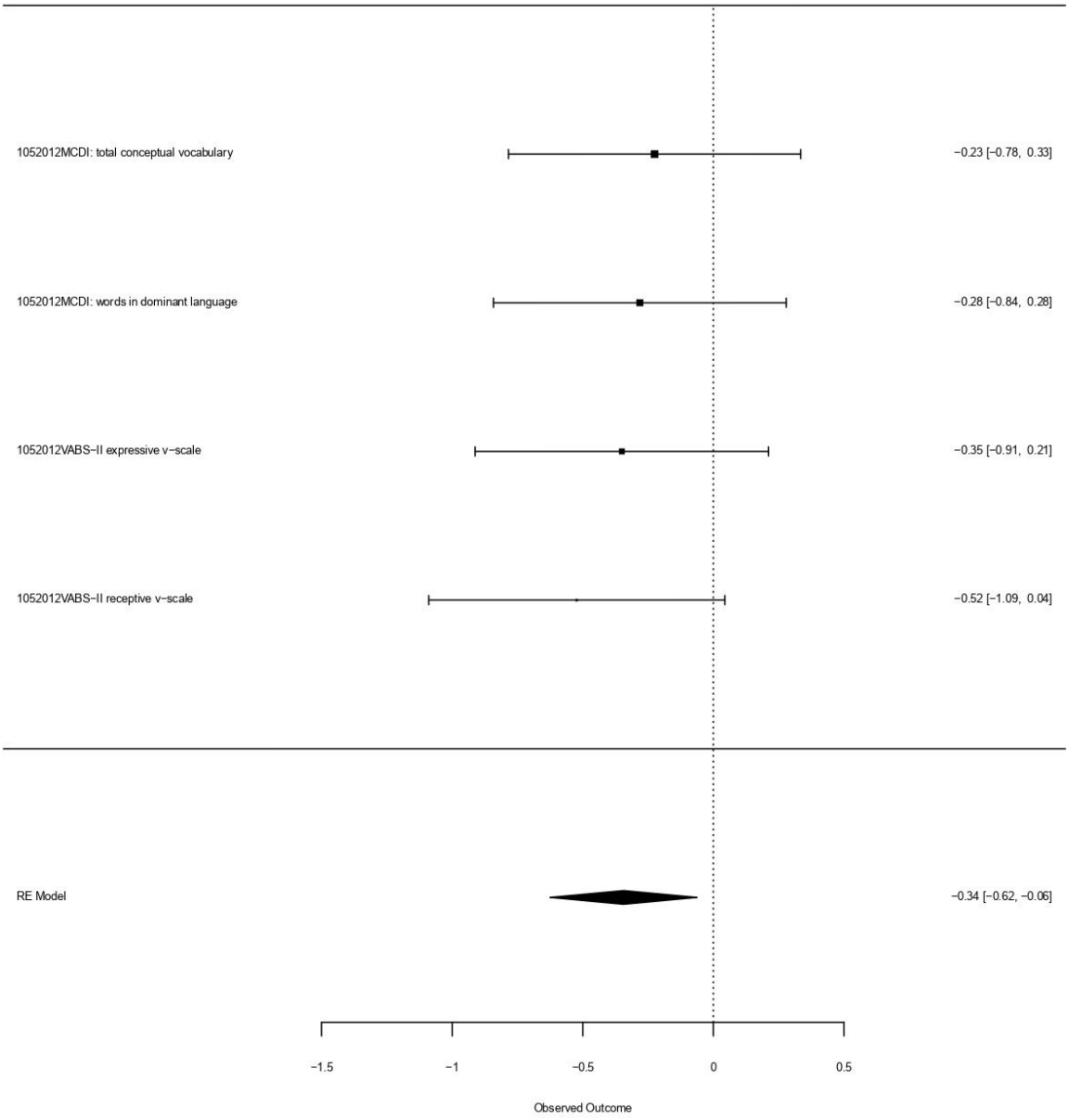

Figure 30 *Linguistic performance (ASDBSIM – ASDM)*

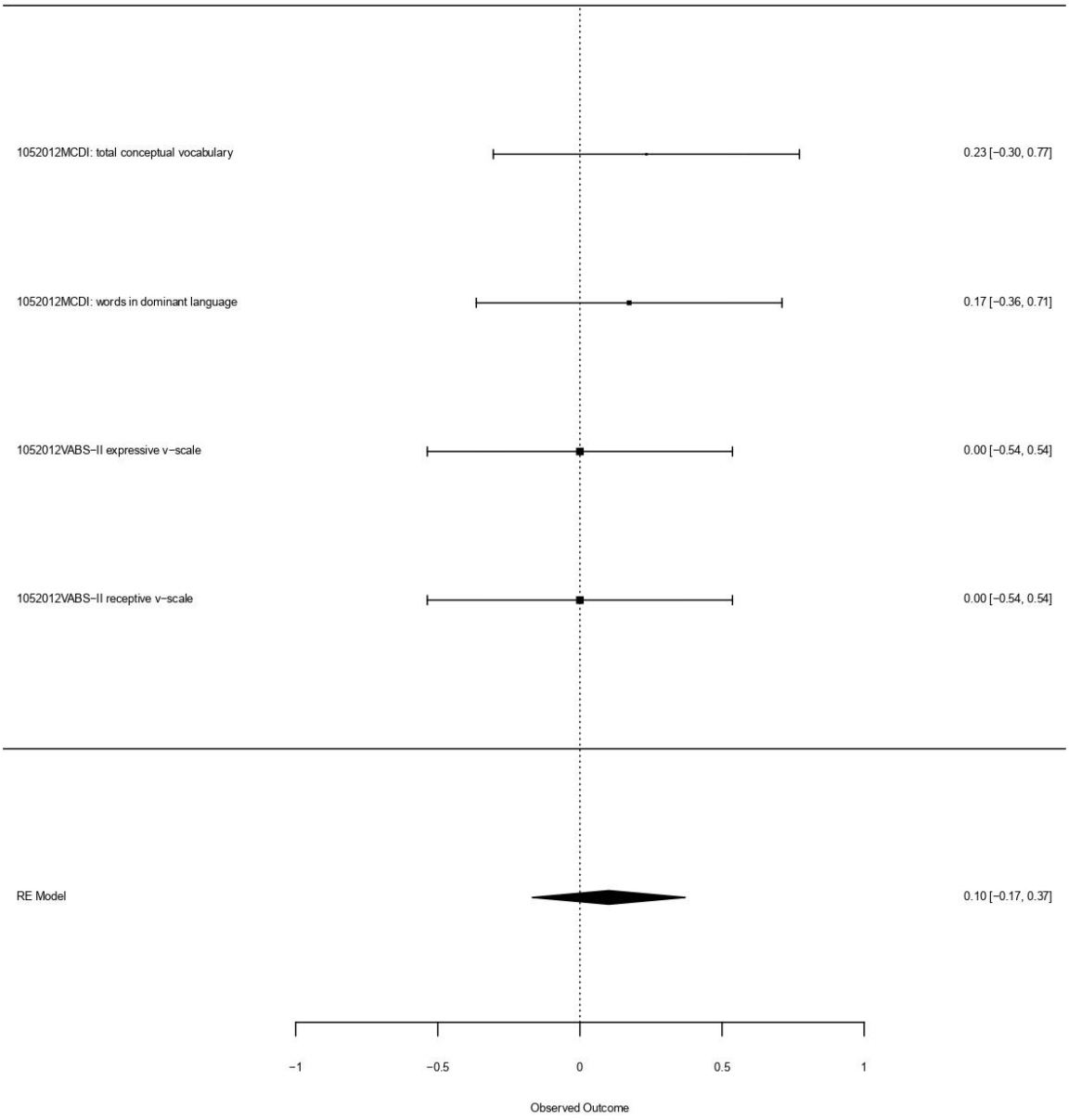

Figure 31 *Linguistic performance (ASDM – TDM)*

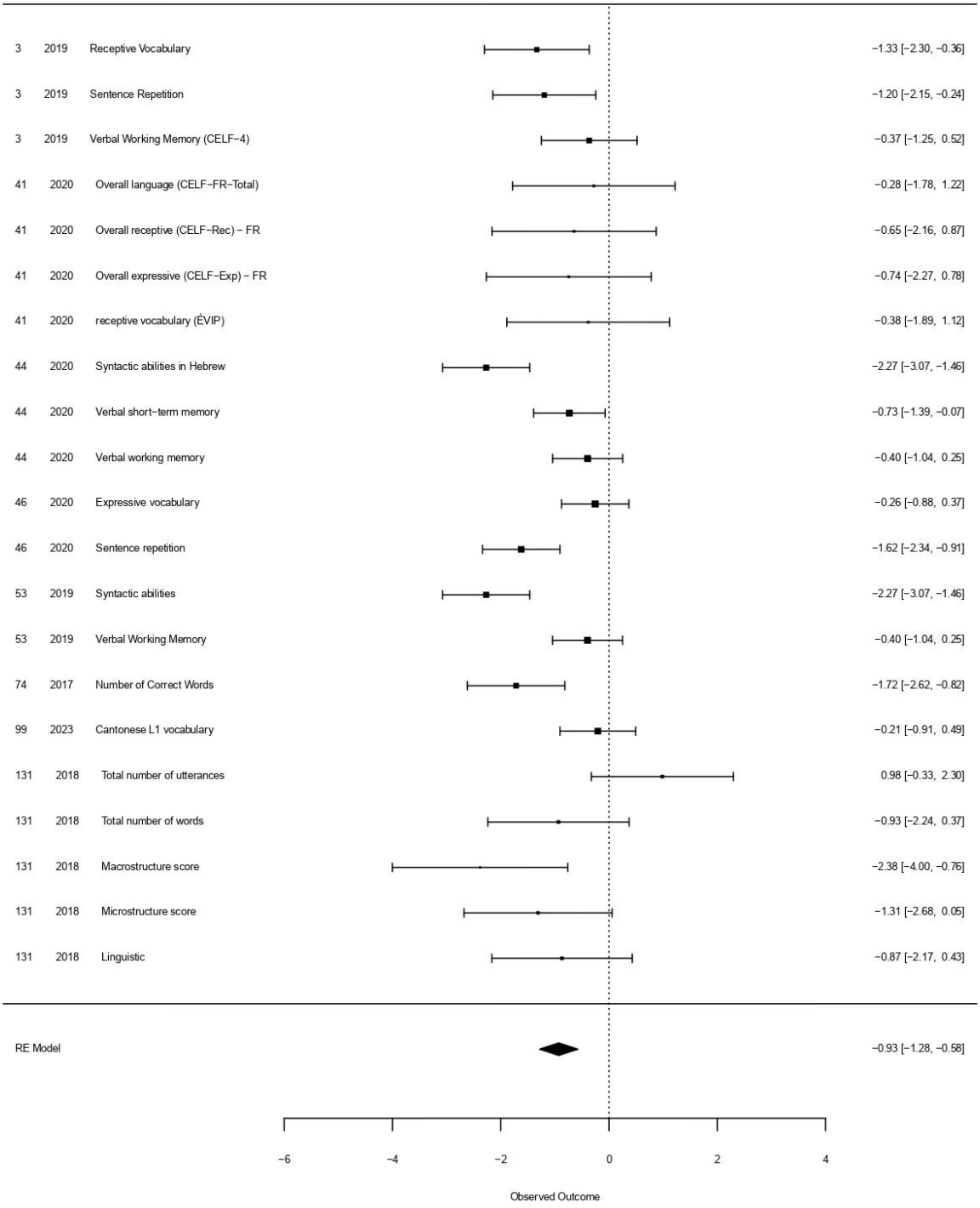

Figure 32 *Linguistic performance (ASDM – TDB)*

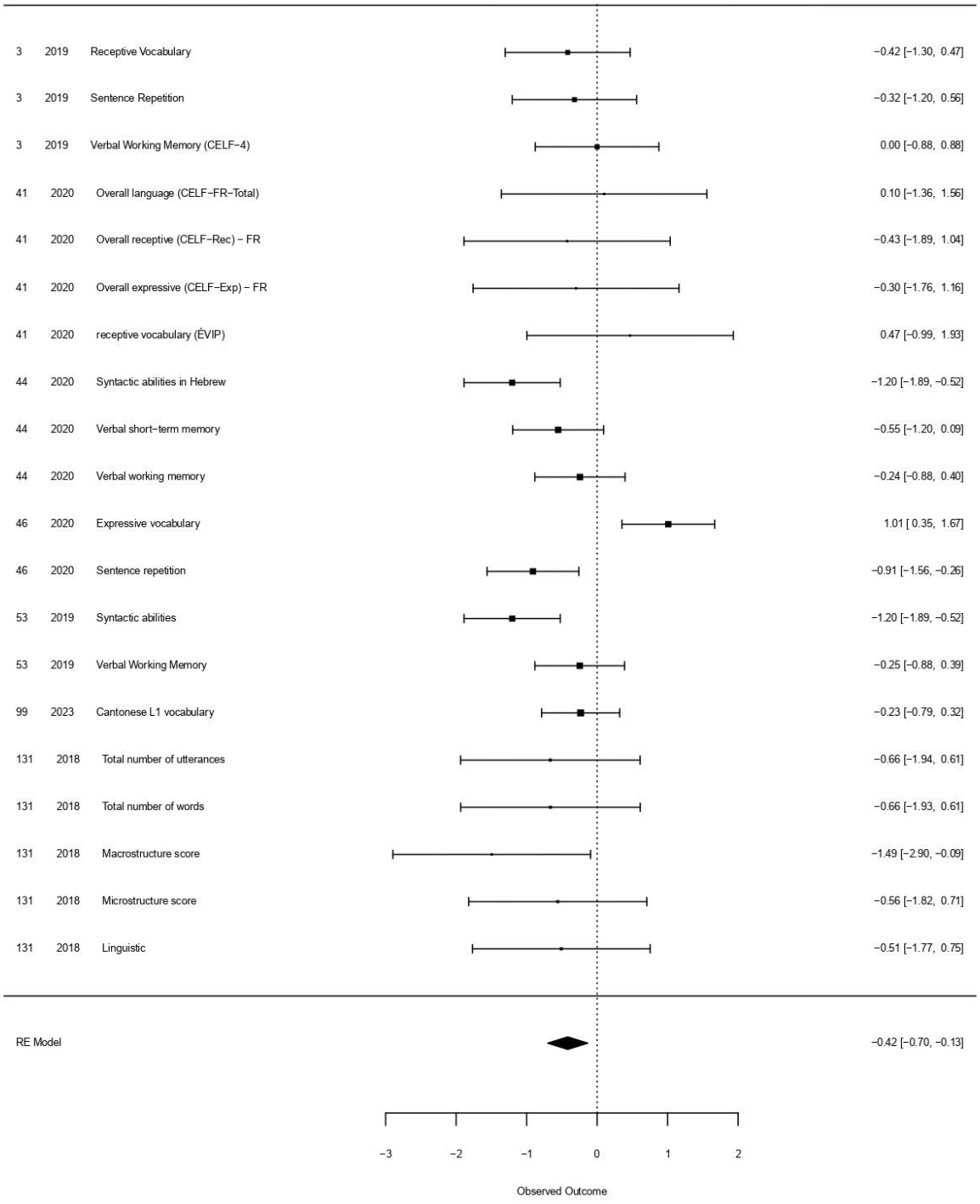

Figure 33 *Funnel plot*