Erschienen in: Clinical Linguistics & Phonetics. Taylor & Francis. 2024, 38(12), S. 1169-1191
https://doi.org/10.1080/02699206.2024.2316288

Attention networks in multilingual adults who do and who do not stutter

Gizem Aslan [a], Theo Marinis [b], and Kurt Eggers [a,c,d]

[a]Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium; [b]Department of Linguistics, University of Konstanz, Konstanz, Germany; [c]Department of Speech-Language Therapy and Audiology, Thomas More, Antwerp, Belgium; [d]Department of Psychology and Speech-Language Pathology, University of Turku, Turku, Finland

ABSTRACT

This study investigated whether multilinguals who stutter differ from multilinguals who do not stutter in terms of attention networks. Towards that end, it measured (a) performance differences in attention networks between multilinguals who stutter and those who do not stutter and (b) the correlation between stuttering characteristics and attention networks. Twenty-four multilingual Dutch-English speaking adults (20–46y), half of whom were diagnosed with stuttering, completed the Attentional Network Task (ANT) that evaluates the attention networks of alerting, orienting, and executive control. A language and social background questionnaire and a lexical decision task (LexTALE) assessed the participants' language proficiency. The Stuttering Severity Instrument 4th Ed. and the Brief Version of the Unhelpful Thoughts and Beliefs About Stuttering Scale were used to evaluate stuttering characteristics. The two groups did not differ in the ANT in terms of reaction time and error rate scores. Furthermore, no differences were observed in the three attention networks between the groups. Lastly, no correlation was found between stuttering characteristics and attention networks. The results suggest that the attention abilities of multilinguals who stutter do not differ from multilinguals who do not stutter.

KEYWORDS

Attention networks; stuttering; multilingualism; bilingualism; adults

Introduction

Stuttering is a multifactorial neurodevelopmental speech disorder, influenced by a complex relationship between linguistic, physiological, environmental, and psychological factors (Smith, 1999; Smith & Weber, 2017). The speech of people who stutter is characterised by disfluencies such as repetitions of sounds, syllables, or monosyllabic words; prolongations of sounds; and/or the inability to initiate sounds, labelled as blocks. These types of '*stuttering-like disfluencies*' (SLD), also defined as overt stuttering behaviours (American Speech-Language-Hearing Association, n.d.), differ from '*other disfluencies*' (e.g. interjections, phrase repetitions) and occur more frequently in the speech of individuals who stutter (Tumanova et al., 2014; Yairi & Seery, 2023). Stuttering may result in speech anxiety and avoidance behaviours and may impact effective communication and social participation (American Psychiatric Association [APA], 2022).

CONTACT Gizem Aslan gizem.aslan@ugent.be Department of Rehabilitation Sciences, Ghent University, Corneel Heymanslaan 10, Ghent 9000, Belgium

Studies in the field of stuttering are predominantly oriented at monolingual speakers (e.g. Bakhtiar & Eggers, 2023; Byrd, Bedore, et al., 2015; Saad Merouwe et al., 2023). Even though the relationship between stuttering and multilingualism has been studied since 1937 (Travis et al., 1937), the data on multilingualism and stuttering are limited and, consequently, systematic research on their relationship is rare (Gahl, 2023; Saad Merouwe et al., 2022). The initial focus of the studies on stuttering and multilingualism was on exploring whether multilingualism was a risk factor for stuttering. Based on a large survey of school-aged children, out of which almost half were multilinguals, Travis et al. (1937) found a higher prevalence of stuttering in multilinguals than in monolingual children. Recently, Gahl (2020) scrutinised Travis et al.'s study and found the raw counts and prevalence rates reported in the study internally inconsistent, thus refuting the conclusions of the study. Also, others have documented the lack of evidence for multilingualism being a risk factor for stuttering (Byrd, Watson, et al., 2015; Packman et al., 2009; Saad Merouwe et al., 2022).

Multilingualism refers to making use of two or more languages in one's daily life (Grosjean, 2010), no matter where, when, and how these languages have been learned and applied (Laviosa & González-Davies, 2019). Chin and Wigglesworth (2007) define multilingualism as 'a continuum with individuals showing varying degrees of competence in each of the language macro skills (speaking, writing, reading, and listening)'. (p.6). Existing research on multilingualism and stuttering has largely focused on how stuttering occurs in multilinguals who stutter (MuWS) and in which language they tend to stutter more (Krawczyk, 2018; Lim et al., 2008). Nwokah (1988) suggested three possible patterns for the manifestation of stuttering in multilinguals: a) stuttering only in one language, b) equal severity of stuttering in all languages and c) less stuttering in (any) one language. The last pattern has received the most support in the literature. Lately, the role of language proficiency on the stuttering severity in different languages of MuWS has also been studied. Language proficiency can be defined as the general ability to produce and comprehend a language, both verbally and written (Werle et al., 2020). The main finding has been that MuWS have a higher stuttering severity in their non-dominant language or in the language they are less proficient in (Al'amri & Robb, 2021; Kashyap & Maruthy, 2020).

Both in people who stutter (e.g. Doneva et al., 2018) as well as in multilinguals (e.g. Chung-Fat-Yim et al., 2022), attention has been studied as a potential contributing factor to sensory, cognitive, and/or emotional between-group differences. Attention is a mechanism that underlies our perception of the world and the self-regulation of our thoughts and emotions (Posner & Rothbart, 2007). Posner and Petersen (1990) have suggested that the attention system can be divided into three separate subareas: alerting, orienting, and executive control (conflict). Alerting refers to the ability to achieve and maintain a state of vigilance to be ready to respond to environmental stimuli; orienting is defined as the selection of information from sensory input; and executive control includes resolving and monitoring conflict among responses (Petersen & Posner, 2012). The alerting network reaches the adult level by late childhood, orienting by mid-childhood and executive control by early adolescence (Rueda & Posner, 2013).

Stuttering and attention networks

Producing speech relies on both language as well as motor speech production mechanisms (Maxfield et al., 2016). This process requires attentional resources to facilitate the activation

of these mechanisms for establishing the necessary movements for fluent speech production (Roelofs & Piai, 2011). Several models (e.g. WEAVER++ model; Roelofs, 2008) propose that attentional resources are required across different stages of the word production process, extending from the word planning phase to the phonological encoding phase (Levelt et al., 1999). The potential link between stuttering and attentional resources has also been addressed (e.g. Eichorn et al., 2019; Singer et al., 2020). According to Ofoe et al. (2018), weaknesses in attention might influence speech, language, and motor skill development, and all of these skills have been involved to some degree in developmental stuttering. Attention skills of adults who stutter (AWS) have been studied using a variety of instruments, ranging from behavioural paradigms (e.g. Test of Everyday Attention; Robertson et al., 1996) to computerised testing of attention networks (e.g. Attention Network Test (ANT); Fan et al. 2002).

Doneva et al. (2018) investigated the attention skills of 25 pairs of AWS and adults who do not stutter (AWNS) using the Test of Everyday Attention. This test evaluates sustained, selective, and divided attention as well as attentional switching. The results revealed that AWS performed significantly worse on the visual selection and divided attention subtests. Furthermore, a significant negative correlation was found between stuttering severity, as measured by the percentage of stuttered syllables, and performance on these two subtests. The authors concluded that better attention skills might be associated with fewer speech disfluencies in speech production. Eggers et al. (2012) used the children's version of the ANT to examine the attention abilities of 41 pairs of children with and without stuttering. The efficiency of the orienting network was found to be significantly lower in the stuttering compared to the nonstuttering group. Albeit limited in number, these studies seem to point to lowered attentional abilities in individuals who stutter. A meta-analysis by Doneva (2020) on stuttering and attention also showed that AWS performed significantly worse than AWNS. Doneva (2020) stated that these findings could also suggest that stuttering sometimes co-occurs with poorer attention abilities.

Attention has also been well-researched in relation to anxiety (Hirsch & Mathews, 2012). Evidence for an impaired executive control network in clients with anxiety disorders has been found (Coussement et al., 2022) as well as links between rumination, perseverative thinking, and decreased executive control (Bernstein et al., 2017). Different studies in the field of stuttering have reported that increased anxiety is common in AWS due to the lifelong stuttering experience (Craig & Tran, 2014; Manning & Beck, 2013). Some have suggested that the need to regulate negative thoughts and experiences might take cognitive resources away from attentional regulation (Johnson et al., 2012) and lower attentional control skills (O'Bryan et al., 2017).

Multilingualism and attention networks

Costa et al. (2008) tested the attention networks of 200 young adults (100 monolinguals, 100 bilinguals) via the ANT. Results showed that bilinguals performed faster than monolinguals on the test. They were more efficient in alerting and executive control subareas. The authors suggested that the group of bilinguals has better attention mechanisms compared to the group of monolinguals. Similarly, Tao et al. (2011) used the ANT to assess the attention networks of 36 early bilinguals, 30 late bilinguals, and 34 monolingual young adults. This study looked at the relationship between the age of acquisition and executive control.

Findings revealed that bilinguals had more advantages in executive control than monolinguals and early bilinguals were found to have a greater advantage than late bilinguals. Another study by Marzecová et al. (2013) investigated the impact of multilingualism on three subareas of attention networks in 35 young adults (17 monolinguals, 18 multilinguals) using the ANT. Marzecová et al. (2013) found that multilinguals had a significantly larger effect in alerting than monolinguals. The multilingual group had also a significantly smaller effect in executive control compared to the monolingual group. Given the discussion on whether or not multilingualism brings an advantage performing in non-verbal tasks (see Grundy, 2020), Bialystok and Craik (2022) suggested that attention control provides a more sufficient explanation for the variety of findings and group differences which would only occur when attention demands of a task go beyond the control abilities of one of the groups. Learning and using a second language depends upon attention networks due to processing and managing more than one language, suppressing interference from language(s) not in use, and navigating and switching between languages (Van den Noort et al., 2019). The latter sometimes results in code-switching (switching between languages either between and/or within utterances; Treffers-Daller et al. (2021)). It is believed that bilingualism may provide beneficial effects on attention networks, and this is why the term *'bilingual advantage'* has been used (Grundy, 2020). On the other hand, some studies reported no bilingual advantage on non-verbal behavioural tasks (Paap, 2019; Paap et al., 2017; Ware et al., 2020). For instance, Paap et al. (2017) examined the bilingual advantage hypothesis by testing 122 bilinguals and 108 monolinguals using non-linguistic tasks such as Colour-Shape switching, Digit-Letter, and Semantic-Category tasks. The bilingual and monolingual groups did not perform significantly different across these tasks.

Purpose of the present study

So far, no study has investigated the attention networks of MuWS. Only two studies in the literature examined the executive functions of bilingual adults who stutter (Kornisch et al., 2017a, 2017b). Executive functions are essential for controlling, managing, and monitoring cognitive behaviours and they modulate attention (Zelazo, 2020). Findings from Kornisch et al. studies revealed that the bilingual stuttering group did not differ from the bilingual non-stuttering group in terms of reaction time and error rate performances. The authors claimed that bilingualism seems to offset deficits in executive functions attributed to stuttering. In light of this, the current study aims to investigate the relationship between stuttering in the non-dominant language and multilingualism in terms of attention networks to provide a better understanding of the relationship between these factors. The research questions of the current study are:

(1) Do MuWS differ from multilinguals who do not stutter (MuWNS) in terms of attention networks? It is difficult to formulate a specific hypothesis for this question because it is unclear how previous findings in monolingual children who stutter can be applied to multilingual adults who stutter.
(2) Is there a correlation between stuttering characteristics and attention networks? We hypothesise that there will be a negative correlation between some of the attention networks and stuttering characteristics, in line with Doneva's et al. (2018) study.

Method

Participants

Twenty-four adults (11 M, 13 F) between 20 and 46 years (M = 27.83; SD = 7.63) participated in the study. They were all paid volunteers and recruited online through word of mouth and social media announcements. All participants spoke Dutch as their first language and English as their second language. Based on a self-reported questionnaire, the participants were divided into two groups: 12 MuWS (6 M, 6 F) as the study group and 12 MuWNS (5 M, 7 F) as the control group. Specific inclusion criteria for MuWS were (a) a diagnosis of stuttering by a speech-language therapist, (b) no history of any speech-language impairment other than stuttering, and (c) no history of any vision and/or hearing impairment. Specific inclusion criteria for MuWNS were to have no history of any speech-language, vision and/or hearing impairment. As shown in Table 1, 21 participants (10 MuWNS, 11 MuWS) reported speaking additional languages. Informed consent was taken at the beginning of testing under a protocol approved by the ethical committee of the University of Konstanz.

Materials and procedure

The study was designed as an online study using Gorilla Experiment Builder (Anwyl-Irvine et al., 2020). This is a cloud-based research platform used by researchers to create and implement online behavioural experiments. A unique web link is provided for each experiment to share with participants; thus, they can open and complete the experiment in their computer browsers (e.g. Google Chrome). This platform was found to be accurate and reliable to run online studies and provide high precision in measuring reaction time (Anwyl-Irvine et al., 2021). To avoid the influence of different browser types, our participants could only access the experiment via Google Chrome. Data were collected during one session for the control group and two sessions for the study group with each online session lasting approximately 45 minutes. Both test sessions started with the first author meeting each participant online via Zoom. The unique Gorilla link was shared with the participants who opened the experiment on their computer. The first author remained on Zoom until the end of each session to ensure that the participants understood the experiment well and were able to ask questions if needed. During the first session, the participants were informed about the different steps of the study, followed by administering a questionnaire, the Attention Network Test, and for the control group a lexical decision test. During the second session (only for the MuWS), a speech sample was collected, followed by completing questionnaires regarding their stuttering history and negative thoughts and beliefs towards stuttering and administering the lexical decision test. The participants were asked to be in a quiet environment where a secure internet connection

Table 1. Demographic and language characteristics.

	Sex		Age						
	Female	Male	M	SD	L1	L2	L3 users	L4 users	L5 users
MuWNS	6	6	27	7.27	Dutch	English	3	2	5
MuWS	5	7	28.86	8.21	Dutch	English	5	3	3

was ensured during the sessions. They were allowed to have short breaks in between the tasks in both sessions.

Evaluation of multilingualism

A *language and social background questionnaire* (see Appendix) was developed based on Coalson et al. (2013) and Choo and Smith's (2020) suggestions to allow for a precise description of the language profiles and demographics of the participants and incorporated some items from the Language History Questionnaire (Li et al., 2006) and the Bilingualism and Emotions Questionnaire (Dewaele, 2010). The questionnaire consisted of five main sections: (a) early language history, i.e. when and how participants' early language skills were acquired (e.g. '*What language or languages did you use in the home when you were a child?*'), (b) language proficiency, i.e. the current language level in four language modalities: speaking, reading, listening, and writing (e.g. '*List all languages you have learned and estimate your level of speaking, listening, reading, and writing in each language.*'), (c) current language use, i.e. the relative use of language during daily routines (e.g. '*Please indicate your current language use.*'), (d) frequency of code-switching, i.e. the frequency and context of switching languages (e.g. '*Please indicate how often you code-switch.*'), and (e) affective variables, i.e. the level of anxiety regarding speaking in other languages (e.g. '*How anxious are you when speaking your different languages?*').

In addition, the Lexical Test for Advanced Learners of English (LexTALE; Lemhöfer & Broersma, 2012) was administered. LexTALE is a lexical decision task, in which participants see words on a computer screen and have to decide whether or not these are existing words in English. It consists of 60 trials, with 40 existing English words and 20 non-existing words. Participants can take as much time as they need for the decision, but the whole task takes about 3 to 5 minutes to complete. The scoring is made based on correct answers, and is determined by the following calculation formula: ((Number of words correct/40 × 100) + (Number of nonwords correct/20 × 100))/2. LexTALE scores have been found to be good predictors of vocabulary knowledge and provide a fair indication of English proficiency (LexTALE; Lemhöfer & Broersma, 2012).

To examine differences between the control and study groups, descriptive analyses, student and Welch's t-tests, and Wilcoxon sum rank tests were carried out on the subareas of the language questionnaire and LexTALE. The results of the questionnaire and the LexTALE can be found in Table 2. The findings showed that the study group had significantly higher scores on Dutch language usage and affective variables in Dutch, while the control group scored significantly higher on the LexTALE. The two groups did not differ in any of the other variables.

Evaluation of attention networks

The Attention Network Task (ANT; Fan et al., 2002) is a computer-based task in which alerting, orienting, and executive control are measured. A summary of the ANT procedure is shown in Figure 1. During the task, participants needed to decide as fast as possible whether the middle arrow of a set of arrows points to the left or the right direction. The arrows were shown either above or below a fixation cross and were supplemented by flankers. The ANT included four cue conditions (no cue, centre, double, spatial) to measure alerting and/or orienting and three flanker conditions (congruent, incongruent, neutral) to measure executive control. Each cue condition provided information on the forthcoming

Table 2. Descriptive and inferential statistics of self-rated language proficiency, age of acquisition, affective variables, code-switching of Dutch and English, and LexTALE in both groups.

	MuWNS (n = 12)			MuWS (n = 12)					
	Mean	SD	Min-Max	Mean	SD	Min-Max	t	*df*	*p*
Dutch									
Self-rating (7-point scale)[c]	6.93	0.15	6.5–7	6.47	1	4–7	–	–	0.17
Age of acquisition (years)[c]	0.58	2.02	0–7	0.66	1.61	0–5	–	–	0.65
Use (%)[c]	36.47	15.41	13.75–64.75	56.28	20.58	13.12–77.70	–	–	0.01*
Affective variables (4-point scale)[c]	0.38	0.59	0–1.6	1.56	0.99	0–3.6	–	–	<0.01**
English									
Self-rating (7-point scale)[c]	6.29	0.38	5.75–7	5.91	1.04	3.25–7	–	–	0.40
Age of acquisition (years)[b]	10	2.41	5–13	11.58	1.72	8–14	−1.84	22	0.07
Use (%)[b]	49.95	18.59	16.25–77.50	37.02	18.90	12.50–83.75	1.69	22	0.10
Affective variables (4-point scale)[a]	0.48	0.43	0–1.3	1.73	0.96	0–2.83	−4.09	15.31	0.99
Code-switching[b]	2.11	0.74	0.5–3	1.97	0.95	0.3–3	0.39	22	0.69
LexTALE (%)[a]	86.09	5.87	73.91–94.30	76.28	11.32	62.27–96.47	2.66	16.51	<0.01**

a: Welch's t-test, b: Student t-test, c: Wilcoxon rank sum; *p < 0.05, **p < 0.01.

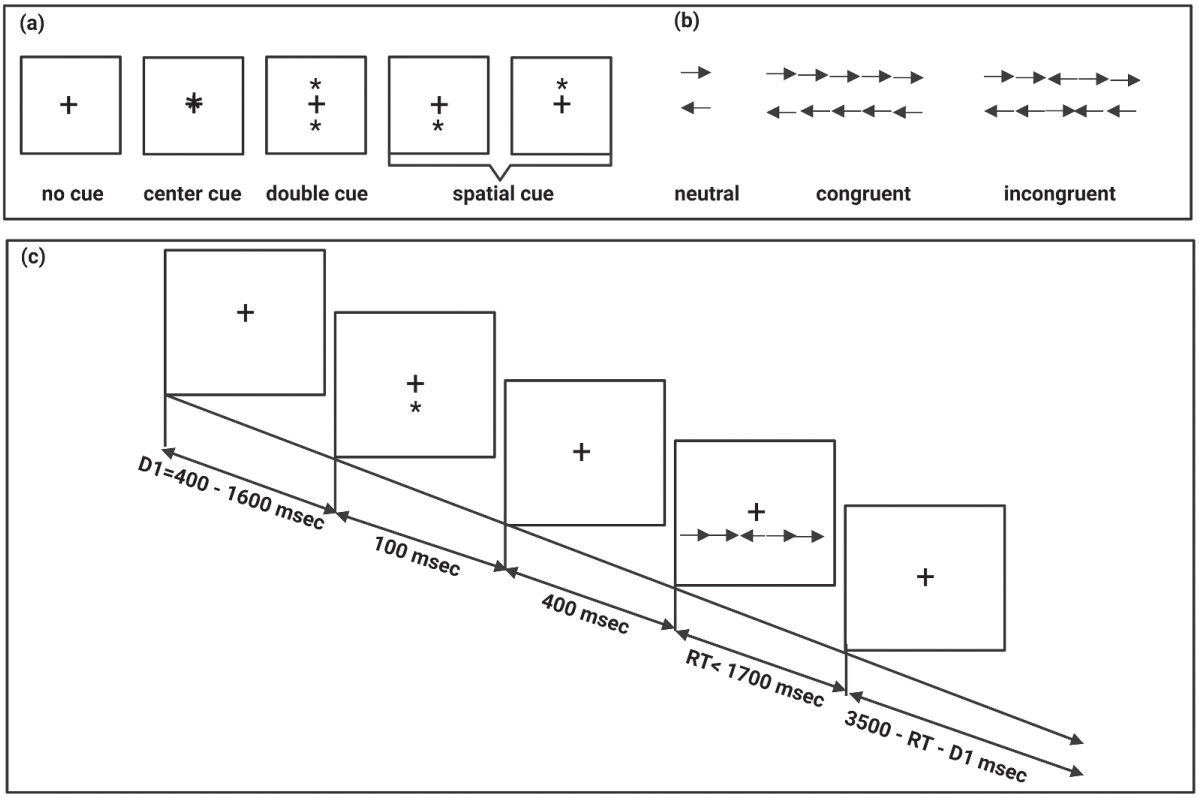


Figure 1. Schematic overview of the attentional networks test. (a) The cue conditions; (b) the flanker condition; and (c) the procedure. Redrawn from Fan et al. (2002).

appearance of the flanker condition. If a cue was either at the centre or double sides of the fixation cross, it indicated that the arrows would appear shortly. If a cue was spatial, it indicated both that the arrows would occur shortly and where they would occur. The test comprised one practice block and three experimental blocks. The practice block consisted of 24 trials with full feedback, whereas each of the three experimental blocks consisted of 96

trials without feedback. The practice block took almost 2 minutes to complete, while each experimental block took about 5 minutes.

In each trial, five events were presented. First, there was the fixation cross which was shown for a random variable time of 400–1600 msec. Following this, one of the cue conditions was presented for 100 msec. Next, the fixation cross was shown again, but this time for 400 msec. This was followed by the presentation of the flanker condition for up to 1700 msec. After a participant gave a response (the '*E*' key for the left and the '*I*' for the right), the flanker condition disappeared right away, and the fixation cross appeared again for a variable duration which was based on the duration of the first fixation cross (D1) and reaction times (RT) in the flanker condition (3500 msec minus the D1 minus RT). Each trial followed the same procedure, and this lasted for 4000 msec. Moreover, the fixation cross was always present in the centre of the screen during the whole trial.

The attention network scores were calculated by measuring how RTs were influenced by the types of cue and flanker conditions. Alerting efficiency was estimated by subtracting the mean RT of the double-cue conditions from the mean RT of the no-cue conditions (Eff. alert.=mean RTno cue – mean RTdouble cue). The efficiency of the orienting network was estimated by subtracting the mean RT of the spatial cue conditions from the mean RT of the central cue conditions (Eff.orient. = mean RTcentral cue – mean RTspatial cue). Lastly, the efficiency of the executive control effect was calculated by subtracting the mean of all RTs for congruent flanker conditions from the mean of all RTs for incongruent flanker conditions (Eff.exec. = mean RTincongruent flanker – mean RTcongruent flanker).

Stuttering assessment

A short questionnaire was created to obtain information on the participants' stuttering history. The MuWS were specifically asked to: (a) provide information about when they were diagnosed with stuttering, (b) rate their stuttering severity using an 8-point self-rating scale (O'Brian et al., 2018, p. 0 = no stuttering, 8 = extremely severe), and (c) provide information on any treatment they might have had (see Table 3).

Stuttering characteristics were evaluated using the Stuttering Severity Instrument – Fourth Ed (SSI-4; Riley, 2009), and the Brief Version of the Unhelpful Thoughts and Beliefs About Stuttering Scales (UTBAS-6; Iverach et al., 2016). The SSI-4 is a valid, standardised tool evaluating stuttering severity based on: (a) the frequency of stuttering occurrences, (b) the duration of stuttering occurrences, and (c) the physical concomitants. To obtain a representative sample of their stuttering behaviour, two types of speech samples were collected: (a) a reading sample and (b) a conversational speech sample. The UTBAS-6 is a scale that is used to measure negative thoughts and beliefs that are associated with social anxiety due to stuttering. MuWS were requested to rate six items (e.g. '*I'll never be successful because of my stutter*') that evaluate the frequency of unhelpful thoughts and beliefs about their stuttering using a 5-point self-rating scale (1 = never or not at all and 5 = always or totally). More specifically, they were asked about how frequently they have these thoughts, how much they believe these thoughts, and how anxious these thoughts make them feel.

All speech samples were video recorded on Zoom. Participants were asked not to use any fluency techniques they might have learned during therapy. The 10 to 15-minute conversational speech sample was collected by the first author based on standard closed and open questions (e.g. hobbies, vacation plans, university/college, work). During the speech sample collection, there was an intentional attempt to begin

Table 3. Individual participant information, stuttering history, and treatment history for multilinguals who stutter along with their overall stuttering rating, stuttering severity instrument - fourth ed. (SSI-4), and the brief version of the unhelpful thoughts and beliefs about stuttering scales (UTBAS-6).

Participant	Age of onset of stuttering (years)	Treatment	Duration of treatment (years)	Rating (8-point scale)	Frequ-ency	Durat-ion	Physical Concomitant	SSI-4	UTBAS-6
P1	4	Yes	14	6	7	6	7	Mild	65
P2	8	Yes	6	3	14	8	5	Moderate	26
P3	4	Yes	4*	3	15	14	9	Very Severe	50
P4	3	Yes	10*	2	12	6	2	Mild	49
P5	4	Yes	10	5	11	8	4	Mild	42
P6	6	Yes	4*	3	13	4	6	Mild	48
P7	3	Yes	10*	3	13	8	6	Moderate	41
P8	5	No	-	3	7	2	2	Very Mild	31
P9	2.5	Yes	7	2	13	10	5	Moderate	47
P10	7	Yes	2	6	7	4	2	Very Mild	45
P11	4	Yes	10	7	17	10	7	Severe	22
P12	5	Yes	12	2	9	6	4	Mild	23

*Stuttering treatment was ongoing at the time of the experiment.

with a familiar topic to avoid any possible breakdowns in the communication. Then, more open-ended questions were gradually provided to increase language output. Samples were only collected in English (not also in Dutch), as the aim of this study was not to examine differences in stuttering manifestations across the languages. The topics of conversations contained a range of topics and the participants were encouraged to produce exclusively English words during the conversation. The first minute of the sample was not included in the analysis: the following 300 consecutive syllables were analysed. For the reading task, the English passage from the SSI-4 was used which consisted of 364 syllables.

The entire analysis was done by the first author, an experienced speech and language therapist with specific training in disfluency analyses. To determine inter-rater reliability, 10% of the samples were analysed independently by the last author. The inter-rater reliability for these samples (point-by-point for location and type, see Ambrose & Yairi, 1999) was calculated based on the 'agreement index' percentage, that is the number of agreements divided by the sum of agreements and disagreements (Suen & Ary, 2014). The inter-rater reliability was 0.94.

Statistical analyses

Statistical analyses were undertaken using R Studio (RStudio Team, 2022). Homogeneity in group variance and normality distribution were calculated for each research group using Levene's and Shapiro-Wilk's tests. The rstatix package was used on R Studio to measure analyses of covariances (ANCOVAs) for investigating the ANT components. It was crucial to consider the performance differences in the LexTALE between the groups during these analyses. Thus, the influence of multilingualism on attention networks was taken into account. Therefore, all between-group analyses included the LexTALE score as a covariate.

Results

Between-group differences in the ANT

RTs and error rates

Trials with RTs greater than 2 SD (approximately 3%) and trials with errors (approximately 2%) were excluded from the RT analysis. To measure differences for each cue and flanker combination, ANCOVAs were performed separately for RTs and error rates. Group was set as independent variable, RT data in each cue and flanker combination as dependent variables, and LexTALE scores as covariate. Results showed no significant between-group effects for RTs, $F(1, 21) = 1.50$, $p = 0.23$, and error rates $F(1, 21) = 0.04$, $p = 0.83$.

Three (flanker type: neutral, congruent, incongruent) × four (cue condition: no, centre, double, spatial) ANCOVA calculations for RTs and error rates were separately carried out for each group with the LexTALE scores as covariate. The interaction between the cue and flanker combination is depicted in Figures 2 and 3. For the MuWS, significant RT main effects of flanker type, $F(2, 131) = 35.17$, $p < 0.001$, and cue condition, $F(3, 131) = 4.75$, $p < 0.01$, were found (Figure 2(a)). Tukey's post hoc comparisons indicated that the average RTs in the incongruent flanker type ($M = 597.48$, $SD = 64.49$) were significantly higher than those in the congruent ($M = 501.91$, $SD = 78.17$, $p < 0.001$) and the neutral ($M = 481.87$, $SD = 78.42$, $p < 0.001$) flanker types. Tukey's post hoc comparisons showed that the average RTs in the no-cue condition ($M = 561.48$, $SD = 75.43$) were significantly higher than in the spatial-cue condition ($M = 498.30$, $SD = 91.40$, $p < 0.01$). No significant interaction effects were observed for RT, $F(6, 131) = 0.46$, $p = 0.83$.

A significant main effect of error rate was found only in the flanker type, $F(2,131) = 25.13$, $p < 0.001$ (Figure 2b). Tukey's post hoc comparisons indicated that the average error rate in the incongruent flanker type ($M = 1.93$, $SD = 2.28$) was significantly higher than that in the congruent ($M = 0.14$, $SD = 0.42$, $p < 0.001$) and the neutral ($M = 0.26$, $SD = 0.68$, $p < 0.001$) flanker types. No significant interaction effects were observed for error rates, $F(6, 131) = 1.40$, $p = 0.21$.

For the MuWNS, a similar pattern emerged. Significant RT main effects of flanker type, $F(2, 131) = 96.07$, $p < 0.001$ and cue condition $F(3, 131) = 14.14$, $p < 0.001$ (Figure 3(a)) were observed. Tukey's post hoc comparisons indicated that: (a) the average RTs in the incongruent flanker type ($M = 560.13$, $SD = 53.15$) were significantly higher than those in the congruent ($M = 470.20$, $SD = 47.46$, $p < 0.001$) and the neutral ($M = 442.42$, $SD = 46.17$, $p < 0.001$) flanker types and (b) the average RTs in the neutral flanker type ($M = 442.42$, $SD = 46.17$) were significantly lower than in the congruent type ($M = 470.20$, $SD = 47.46$, $p < 0.01$). Tukey's post hoc comparisons showed that: (a) the average RTs in the no-cue condition ($M = 523.13$, $SD = 57.63$) were significantly higher than in the spatial-cue condition ($M = 456.75$, $SD = 62.23$, $p < 0.001$), (b) the average RTs in the double-cue condition ($M = 488.49$, $SD = 74.32$) were significantly lower than in the no-cue condition ($M = 523.13$, $SD = 57.63$, $p < 0.01$) and higher than the spatial-cue condition ($M = 456.75$, $SD = 62.23$, $p < 0.05$), and (c) the average RTs in the centre-cue condition ($M = 495.30$, $SD = 71.09$) were significantly lower than in the no-cue condition ($M = 523.13$, $SD = 57.63$, $p < 0.05$) and higher than in the spatial-cue condition ($M = 456.75$, $SD = 62.23$, $p < 0.01$). No significant interaction effects were observed for RT, $F(6, 131) = 0.93$, $p = 0.47$.

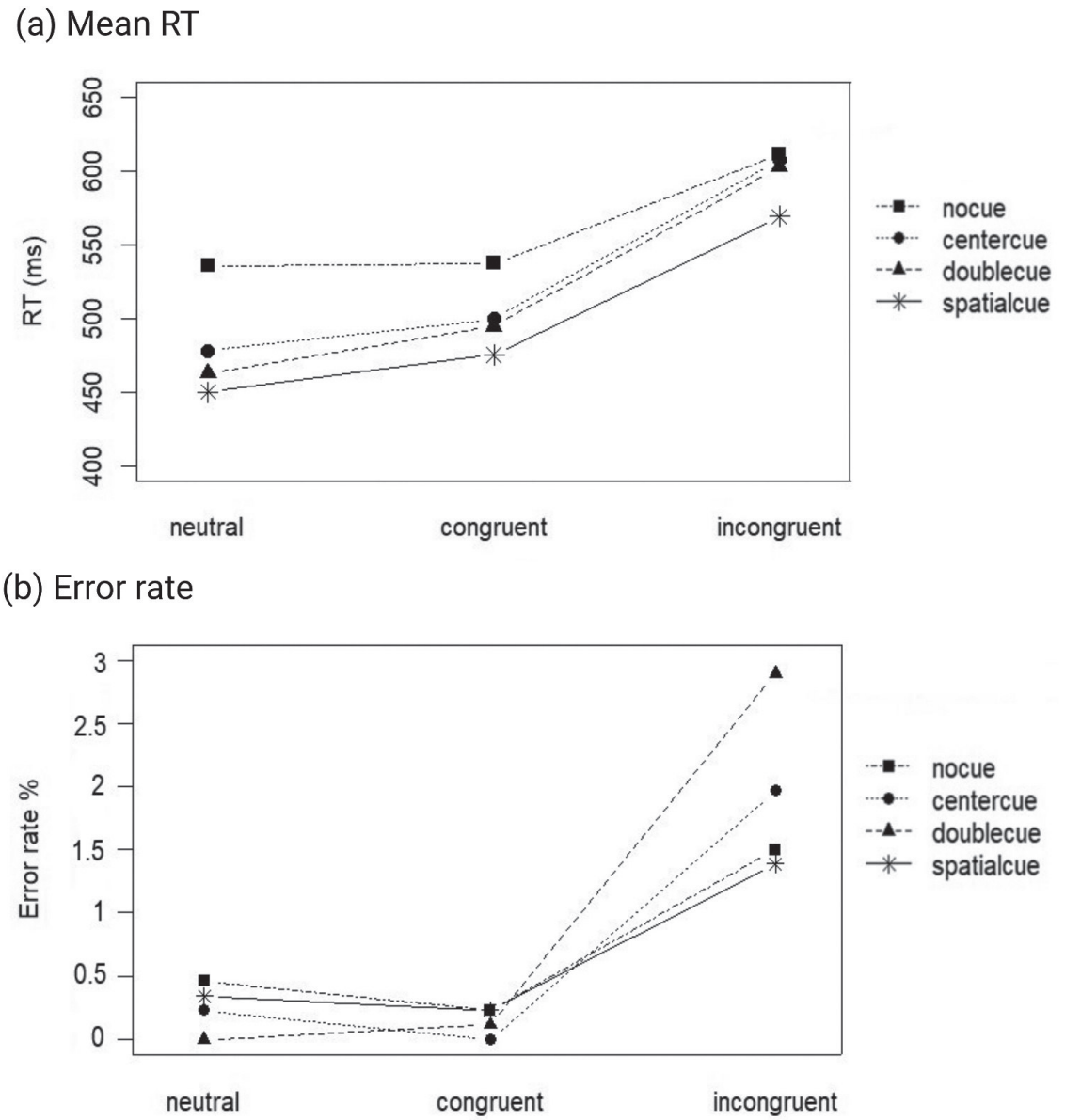


Figure 2. Mean RT (a) and error rate (b) in each cue and flanker conditions for multilinguals who stutter (MuWS).

A significant error rate main effect was also found only in the flanker type, $F(2,131) = 24.87$, $p < 0.001$ (Figure 3(b)). Tukey's post hoc comparisons indicated that the average error rate in the incongruent flanker type (M = 1.41, SD = 1.47) was significantly higher than the one in the congruent (M = 0.05, SD = 0.40, $p < 0.001$) and the neutral (M = 0.31, SD = 0.77, $p < 0.001$) flanker types. No significant interaction effects were observed for error rates, $F(6, 131) = 0.85$, $p = 0.52$.

Attention networks

Between-group differences in attention network scores were examined using ANCOVAs. Participant group was set as independent variable, alerting, orienting, and conflict scores as dependent variables, and LexTALE scores as covariate. Table 4 shows the efficiency scores of each attentional network in both groups. No significant between-group differences were observed for the alerting scores F(1,21)

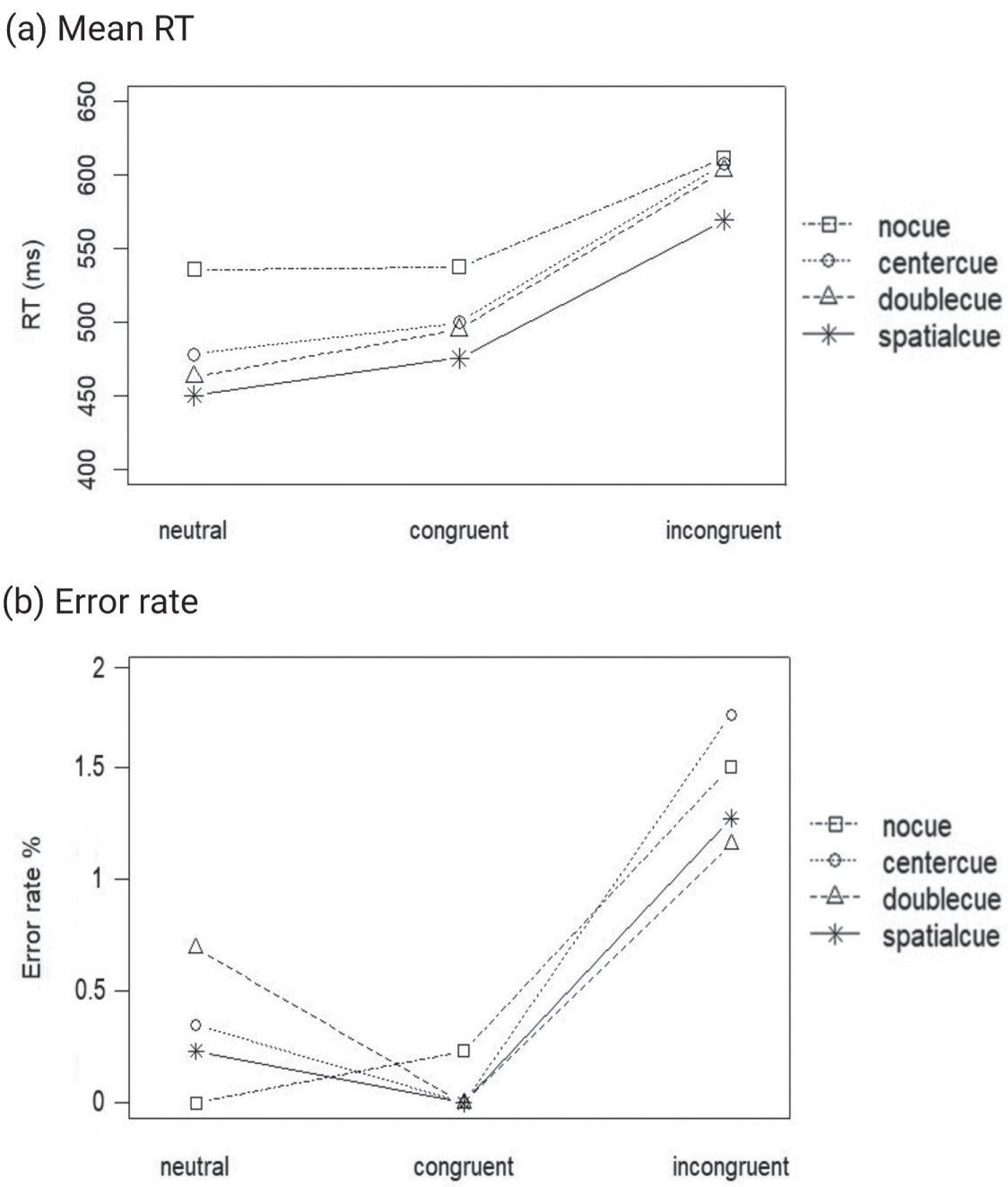


Figure 3. Mean RT (a) and error rate (b) in each cue and flanker conditions for multilinguals who do not stutter (MuWNS).

= 1.18, $p = 0.28$, $\eta_p^2 = 0.053$, orienting scores $F(1,21) = 1.71$, $p = 0.20$, $\eta_p^2 = 0.075$, and executive control scores $F(1,21) = 0.02$, $p = 0.87$, $\eta_p^2 = 0.001$ (see Figure 4).

Correlation between stuttering characteristics and attention networks

Pearson correlational analyses were performed to evaluate the correlation between attention networks and stuttering characteristics in MuWS. The correlation examination of stuttering characteristics and attention networks was done between the SSI-4 scores (frequency, physical concomitants, and duration) and three attention networks as well as between the

Table 4. Efficiency scores in alerting, orienting, and conflict in multilinguals who stutter (MuWS) and multilinguals who do not stutter (MuWNS).

	MuWNS		MuWS	
	Mean	SD	Mean	SD
Alerting	34.60	14.95	44.21	15.83
Orienting	37.49	16.22	29.63	18.46
Executive Control	89.69	19.29	95.36	23.65

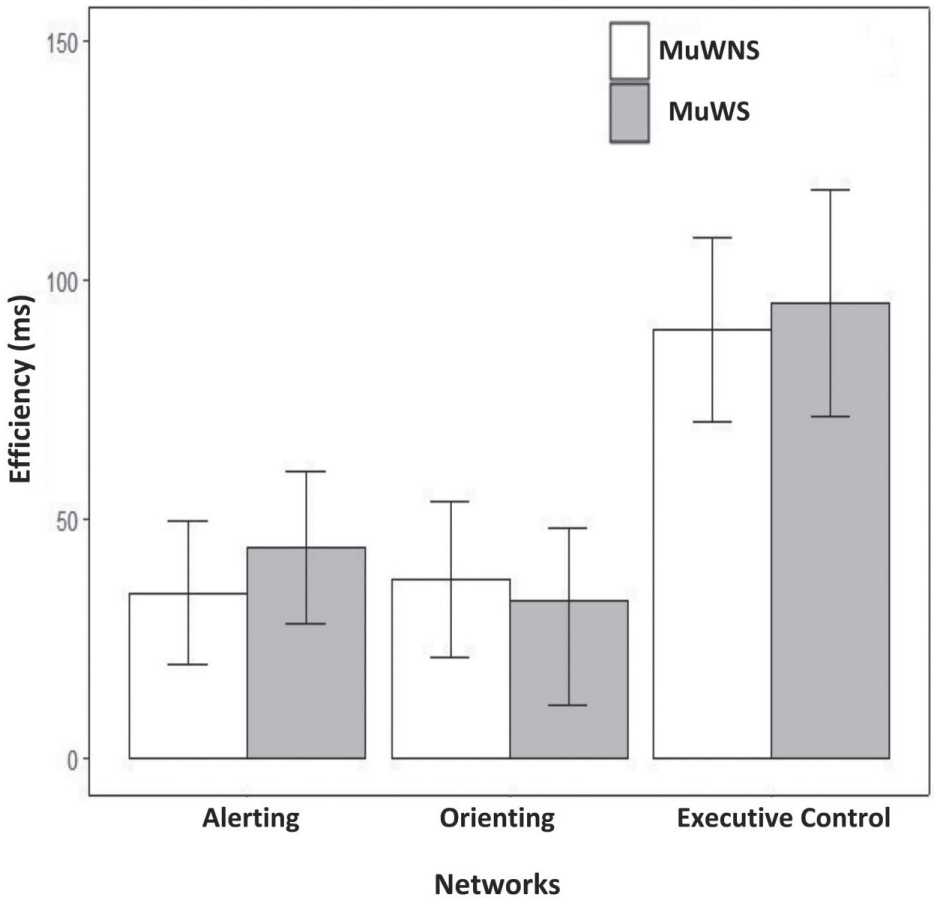


Figure 4. Attention network scores for the multilinguals who stutter (MuWS) and multilinguals who do not stutter (MuWNS).

UTBAS-6 total scores and three attention networks. None of these analyses reached statistical significance ($p > 0.05$) (see Table 5).

Discussion

This study addressed the efficiency of attention networks in MuWS. The limited research so far in bilinguals who stutter has shown no differences in executive functions between bilinguals who stutter and those who do not stutter. The present study aimed at filling this gap by comparing the attention networks between MuWS and MuWNS, and by investigating the relationship between stuttering characteristics and attention network performance. No prior study so far has used the ANT paradigm in MuWS.

Table 5. Pearson correlation matrix between stuttering characteristic measurements and three attention networks.

	SSI-4									
	Frequency		Physical Concomitant		Duration		Total Score		UTBAS-6	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Alerting	−0.24	0.43	−0.12	0.70	−0.33	0.29	−0.27	0.38	−0.22	0.47
Orienting	−0.10	0.75	−0.29	0.34	0.18	0.55	−0.05	0.87	0.12	0.70
Executive Control	−0.23	0.45	−0.24	0.44	−0.22	0.47	−0.26	0.40	0.11	0.71

MuWS and MuWNS did not differ in RT and error rate

No significant between-group differences were found for RTs or error rate percentages for the cue flanker combinations. Incongruent flankers led to an increase in RTs and error rates in both groups, similar to the findings from previous adult studies (Costa et al., 2008; Fan et al., 2002; Marzecová et al., 2013). Spatial cues reduced RTs for both groups, similar to the findings from the previous studies (Costa et al., 2008; Fan et al., 2002); however, it did not have any effect on the percentage of errors. These similarities with the previous literature confirm the validity of the current testing procedures. In our study, we did not find an interaction effect between cue type and flanker conditions, which is different from the findings of Costa et al. (2008) and Fan et al. (2002). The reason for that could possibly be attributed to methodological differences in statistical analysis (ANCOVA with LexTALE as covariate versus ANOVA) or participant criteria (multilingual stuttering and non-stuttering participants versus mono-/bilingual nonstuttering).

In comparison to Fan et al. (2002), who had a similar age group as the participants in our study, the mean error rates were considerably lower in our multilingual group. In other words, both MuWS and MuWNS in our study made less errors than the monolingual participants in Fan et al. Mean error percentages for multilinguals in the current study and the participants in Fan et al. were respectively 0.09 (SD = 0.41) and 0.57 (SD = 0.19) for the congruent trials, 1.67 (SD = 1.87) and 4.03 (SD = 0.63) for the incongruent trials, and 0.28 (SD = 0.73) and 1.11 (SD = 0.26) for neutral trials. In addition, based on the previous literature (Doneva, 2020), one would expect the stuttering group to have lower RTs but our MuWS had comparable RTs to both our MuWNS and Fan et al.'s participant group. Therefore, these findings seem to map onto the previously reported bilingualism advantage (e.g. Kornisch et al., 2017b). However, one cannot be certain that these differences might not also have been influenced by methodological differences between our study and Fan et al. In the study by Kornisch et al., 40 bilingual adults (half of whom stuttered) and 40 monolinguals (also half of whom stuttered) were presented with a selective identification task where objects were presented simultaneously to both visual fields with an arrow in between. Based on the direction of the arrow, participants had to select the correct word in a subsequent screen. No significant differences were found between the bilingual stuttering and nonstuttering groups. However, the bilingual participants, regardless of stuttering, had faster reaction times and fewer identification errors than monolingual participants. The authors also interpreted this finding as indicative of a bilingualism benefit.

MuWS and MuWNS did not differ in attention networks

Doneva et al. (2018) observed that monolingual AWS performed significantly worse than AWNS on visual selection (overlapping with the orienting network) and divided attention (overlapping with the executive control network) subtests. In our study with multilingual adults, we did not find such a difference between the stuttering and nonstuttering groups. According to D'Souza et al. (2020), multilinguals alternate their attention more frequently than monolinguals because they continuously have to navigate or shift between two or more languages and this shifting between languages results in better adaptation skills in the attention system of adults (D'Souza et al., 2021). Some ANT-based studies actually documented that bilinguals, compared to monolinguals, have an advantage in the efficiency of attentional networks, especially in the executive control network (Costa et al., 2008; Marzecová et al., 2013; Tao et al., 2011). The fact that we did not find any between-group differences in multilingual adults, might map onto the claim by Kornisch et al. (2017a) that bilingualism might counterbalance some of the deficits in attention networks that are attributed to stuttering. The same participant group as in Kornisch et al. (2017b), discussed higher up, was administered a dual-task paradigm. Their results also showed that there were no performance differences between bilinguals who stutter and those who do not stutter, and monolinguals who stutter experienced more dual-task interference compared to bilinguals who stutter and monolinguals who do not stutter.

No correlation between stuttering characteristics and attention networks

No significant correlations between stuttering characteristics, as measured by the SSI-4 and UTBAS-6, and the three attentional networks. This is in line with the nonsignificant results of previous studies correlating SSI-4 scores with inhibitory control, which conceptually overlaps with the executive control network (Tendera, 2019; Treleaven & Coalson, 2020, 2021). In contrast, Doneva et al. (2018) did find a significant negative correlation between SLD frequency and the performance on the visual selection and divided attention resources subcomponent of the Test of Everyday Attention. Somewhat oddly however, they defined SLD as 'repetitions, prolongations, blocks, interjections, and revisions in speech'. (p.548), while it is well known that interjections and revisions are no indicators of stuttering severity and should be classified as 'other disfluencies' and not SLD (Yairi & Seery, 2023). So, this could be one of the reasons for their dissonant finding.

No studies have looked into the correlation between the UTBAS-6 and attentional networks previously but there were some studies correlating inhibitory control performance with the Overall Assessment of the Speaker's Experience with Stuttering (OASES; Yaruss & Quesal, 2006). OASES and UTBAS-6 tap into slightly different aspects of stuttering characteristics; while UTBAS-6 only measures negative thoughts and beliefs, OASES evaluates general perspectives, reactions to stuttering, functional communication difficulties, and the impact on the quality of life. The UTBAS-6 overlaps most with the OASES section on reactions to stuttering. The findings from these studies are ambiguous. Some studies, such as Treleaven and Coalson (2021), did not find a correlation, while others (Tendera, 2019; Treleaven & Coalson, 2020) observed correlations – albeit sometimes specifically with the overall OASES score or *Quality of Life* subsection. Furthermore, the aforementioned studies did not provide clear information on their participants' language profiles. It seems that their

AWS groups were a mix of bilingual and monolingual adults. Therefore, comparison with these studies is very difficult as well as making statements about the possible effect of bilingualism on negative emotions and thoughts related to stuttering.

Limitations and future research directions

The current study has some limitations. First, the experimental group is rather limited which warrants some caution in interpreting these findings and replication with a larger participant group would be appropriate. On the other hand, the domain of multilingualism and stuttering is an unexplored area so the findings add value and will prompt additional research in this population. Second, the fact that there is no other study that has compared attention networks in MuWS allows us only to compare the current findings to previous studies mainly based on monolinguals who stutter. Third, the current study was conducted online while the other studies took place in person. Fourth, because stuttering severity scores might have been impacted by treatment, future studies would benefit from collecting more detailed information about the kind of treatment, and if possible in this age group, to have a better balance between participants with and without treatment. Finally, the inclusion of a monolingual participant group in this study would have been ideal to obtain a more detailed insight into whether current findings were impacted by a bilingual advantage or not. However, in countries like Belgium and the Netherlands bilingualism is the norm, making it very difficult to find an adequate number of monolingual Dutch (young) AWS.

Further research in the field of multilingualism and stuttering should help determine whether attentional processes differ between multilinguals who do and do not stutter and could further our present understanding of the manifestation of stuttering as well as to what extent attentional processes play a role in stuttering characteristics of both MuWS and MuWNS.

Conclusion

The current study provides some emerging insights into the relationship between stuttering, multilingualism, and attention networks. The efficiency of attention networks in multilingual stuttering adults was statistically equal to their nonstuttering counterparts. Stuttering characteristics were not related to attention networks.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Gizem Aslan http://orcid.org/0009-0004-2207-8922
Theo Marinis http://orcid.org/0000-0002-4120-3141
Kurt Eggers http://orcid.org/0000-0003-4221-2063

References

Al'amri, F., & Robb, M. P. (2021). Disfluency characteristics of Omani Arabic-English bilingual speakers. *Clinical Linguistics & Phonetics*, *35*(7), 593–609. https://doi.org/10.1080/02699206.2020.1806931

Ambrose, N. G., & Yairi, E. (1999). Normative disfluency data for early childhood stuttering. *Journal of Speech, Language, and Hearing Research*, *42*(4), 895–909. https://doi.org/10.1044/jslhr.4204.895

American Psychiatric Association. (2022). Cautionary statement for forensic use of DSM-5. In *Diagnostic and statistical manual of mental disorders*. American Psychiatric Association Publishing. https://doi.org/10.1176/appi.books.9780890425787.Cautionary_Statement_for_Forensic_Use_of_DSM_5

American Speech-Language-Hearing Association. (n.d.). *Fluency disorders (practice portal)*. American Speech-Language-Hearing Association. Retrieved July 4, 2023, from https://www.asha.org/practice-portal/clinical-topics/fluency-disorders/

Anwyl-Irvine, A., Dalmaijer, E. S., Hodges, N., & Evershed, J. K. (2021). Realistic precision and accuracy of online experiment platforms, web browsers, and devices. *Behavior Research Methods*, *53*(4), 1407–1425. https://doi.org/10.3758/s13428-020-01501-5

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388–407. https://doi.org/10.3758/s13428-019-01237-x

Bakhtiar, M., & Eggers, K. (2023). Exogenous verbal response inhibition in adults who do and do not stutter. *Journal of Fluency Disorders*, *75*, 105957. https://doi.org/10.1016/j.jfludis.2022.105957

Bernstein, E. E., Heeren, A., & McNally, R. J. (2017). Unpacking rumination and executive control: A network perspective. *Clinical Psychological Science*, *5*(5), 816–826. https://doi.org/10.1177/2167702617702717

Bialystok, E., & Craik, F. I. M. (2022). How does bilingualism modify cognitive function? Attention to the mechanism. *Psychonomic Bulletin & Review*, *29*(4), 1246–1269. https://doi.org/10.3758/s13423-022-02057-5

Byrd, C. T., Bedore, L. M., & Ramos, D. (2015). The disfluent speech of bilingual Spanish-English children: Considerations for differential diagnosis of stuttering. *Language, Speech, and Hearing Services in Schools*, *46*(1), 30–43. https://doi.org/10.1044/2014_LSHSS-14-0010

Byrd, C. T., Watson, J., Bedore, L., & Mullis, A. (2015). Identification of stuttering in bilingual Spanish-English speaking children. *Contemporary Issues in Communication Science and Disorders*, *42*(Spring), 72–87. https://doi.org/10.1016/s0094-730x(03)00004-4

Chin, N. B., & Wigglesworth, G. (2007). *Bilingualism: An advanced resource book*. Taylor & Francis.

Choo, A. L., & Smith, S. A. (2020). Bilingual children who stutter: Convergence, gaps and directions for research. *Journal of Fluency Disorders*, *63*, 105741. https://doi.org/10.1016/j.jfludis.2019.105741

Chung-Fat-Yim, A., Calvo, N., & Grundy, J. G. (2022). The multifaceted nature of bilingualism and attention. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.910382

Coalson, G. A., Peña, E. D., & Byrd, C. T. (2013). Description of multilingual participants who stutter. *Journal of Fluency Disorders*, *38*(2), 141–156. https://doi.org/10.1016/j.jfludis.2013.02.008

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*, *106*(1), 59–86. https://doi.org/10.1016/j.cognition.2006.12.013

Coussement, C., De Longueville, X., & Heeren, A. (2022). Attentional networks in co-occurring generalized anxiety disorder and major depression disorder: Towards a staging approach to the executive control deficits. *Comprehensive Psychiatry*, *113*, 152294. https://doi.org/10.1016/j.comppsych.2021.152294

Craig, A., & Tran, Y. (2014). Trait and social anxiety in adults with chronic stuttering: Conclusions following meta-analysis. *Journal of Fluency Disorders*, *40*, 35–43. https://doi.org/10.1016/j.jfludis.2014.01.001

D'Souza, D., Brady, D., Haensel, J. X., & D'Souza, H. (2020). Is mere exposure enough? The effects of bilingual environments on infant cognitive development. *Royal Society Open Science*, *7*(2), 180191. https://doi.org/10.1098/rsos.180191

D'Souza, D., Brady, D., Haensel, J. X., & D'Souza, H. (2021). Early bilingual experience is associated with change detection ability in adults. *Scientific Reports*, *11*(1), Article 1. https://doi.org/10.1038/s41598-021-81545-5

Dewaele, J.-M. (2010). *Emotions in multiple languages*. Palgrave Macmillan UK. https://doi.org/10.1057/9780230289505

Doneva, S., Davis, S., & Cavenagh, P. (2018). Comparing the performance of people who stutter and people who do not stutter on the test of everyday attention. *Journal of Clinical and Experimental Neuropsychology*, *40*(6), 544–558. https://doi.org/10.1080/13803395.2017.1386162

Doneva, S. P. (2020). Adult stuttering and attentional ability: A meta-analytic review. *International Journal of Speech-Language Pathology*, *22*(4), 444–453. https://doi.org/10.1080/17549507.2019.1665710

Eggers, K., De Nil, L. F., & Van den Bergh, B. R. H. (2012). The efficiency of attentional networks in children who stutter. *Journal of Speech, Language, and Hearing Research: JSLHR*, *55*(3), 946–959. https://doi.org/10.1044/1092-4388(2011/10-0208)

Eichorn, N., Pirutinsky, S., & Marton, K. (2019). Effects of different attention tasks on concurrent speech in adults who stutter and fluent controls. *Journal of Fluency Disorders*, *61*, 105714. https://doi.org/10.1016/j.jfludis.2019.105714

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340–347. https://doi.org/10.1162/089892902317361886

Gahl, S. (2020). Bilingualism as a purported risk factor for stuttering: A close look at a seminal study (Travis et al., 1937). *Journal of Speech, Language, & Hearing Research*, *63*(11), 3680–3684. https://doi.org/10.1044/2020_JSLHR-20-00364

Gahl, S. (2023). Bilingualism as a risk factor for false reports of stuttering in the early childhood longitudinal study (ECLS-K: 2011). *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1155895

Grosjean, F. (2010). *Bilingual*. Harvard University Press.

Grundy, J. G. (2020). The effects of bilingualism on executive functions: An updated quantitative analysis. *Journal of Cultural Cognitive Science*, *4*(2), 177–199. https://doi.org/10.1007/s41809-020-00062-5

Hirsch, C. R., & Mathews, A. (2012). A cognitive model of pathological worry. *Behaviour Research and Therapy*, *50*(10), 636–646. https://doi.org/10.1016/j.brat.2012.06.007

Iverach, L., Heard, R., Menzies, R., Lowe, R., O 'brian, S., Packman, A., & Onslow, M. (2016). A brief version of the unhelpful thoughts and beliefs about stuttering scales: The UTBAS-6. *Journal of Speech, Language, & Hearing Research*, *59*(5), 964–972. https://doi.org/10.1044/2016_JSLHR-S-15-0167

Johnson, K. N., Conture, E. G., & Walden, T. A. (2012). Efficacy of attention regulation in preschool-age children who stutter: A preliminary investigation. *Journal of Communication Disorders*, *45*(4), 263–278. https://doi.org/10.1016/j.jcomdis.2012.04.001

Kashyap, P., & Maruthy, S. (2020). Stuttering frequency and severity in Kannada-English balanced bilingual adults. *Clinical Linguistics & Phonetics*, *34*(3), 271–289. https://doi.org/10.1080/02699206.2019.1637459

Kornisch, M., Robb, M. P., & Jones, R. D. (2017a). Estimates of functional cerebral hemispheric differences in monolingual and bilingual people who stutter: Dual-task paradigm. *Clinical Linguistics & Phonetics*, *31*(6), 409–423. https://doi.org/10.1080/02699206.2017.1305448

Kornisch, M., Robb, M. P., & Jones, R. D. (2017b). Estimates of functional cerebral hemispheric differences in monolingual and bilingual people who stutter: Visual hemifield paradigm. *Clinical Linguistics & Phonetics*, *31*(4), 251–265. https://doi.org/10.1080/02699206.2016.1240236

Krawczyk, A. (2018). *Crosslinguistic analysis of stuttering and typical disfluencies in Polish-English bilingual adults who stutter* [Electronic Theses and Dissertations]. https://stars.library.ucf.edu/etd/5955

Laviosa, S., & González-Davies, M. (Eds.). (2019). *The Routledge handbook of translation and education* (1st ed.). Routledge. https://doi.org/10.4324/9780367854850

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: A quick and valid lexical test for advanced learners of English. *Behavior Research Methods*, *44*(2), 325–343. https://doi.org/10.3758/s13428-011-0146-0

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*(1), 1–38. https://doi.org/10.1017/S0140525X99001776

Li, P., Sepanski, S., & Zhao, X. (2006). Language history questionnaire: A Web-based interface for bilingual research. *Behavior Research Methods*, *38*(2), 202–210. https://doi.org/10.3758/BF03192770

Lim, V. P. C., Lincoln, M., Chan, Y. H., & Onslow, M. (2008). Stuttering in English–mandarin bilingual speakers: The influence of language dominance on stuttering severity. *Journal of Speech, Language, and Hearing Research*, *51*(6), 1522–1537. https://doi.org/10.1044/1092-4388(2008/07-0054)

Manning, W., & Beck, J. (2013). The role of psychological processes in estimates of stuttering severity. *Journal of Fluency Disorders*, *38*(4), 356–367. https://doi.org/10.1016/j.jfludis.2013.08.002

Marzecová, A., Asanowicz, D., Krivá, L., & Wodniecka, Z. (2013). The effects of bilingualism on efficiency and lateralization of attentional networks. *Bilingualism: Language and Cognition*, *16*(3), 608–623. https://doi.org/10.1017/S1366728912000569

Maxfield, N. D., Olsen, W. L., Kleinman, D., Frisch, S. A., Ferreira, V. S., & Lister, J. J. (2016). Attention demands of language production in adults who stutter. *Clinical Neurophysiology*, *127*(4), 1942–1960. https://doi.org/10.1016/j.clinph.2016.01.016

Nwokah, E. E. (1988). The imbalance of stuttering behavior in bilingual speakers. *Journal of Fluency Disorders*, *13*(5), 357–373. https://doi.org/10.1016/0094-730X(88)90004-6

O'Brian, S., Carey, B., Lowe, R., Onslow, M., Packman, A., & Cream, A. (2018). *The camper-down program stuttering treatment guide*. Australian Stuttering Research Centre. https://www.uts.edu.au/sites/default/files/2021-04/Camperdown%20Program%20Treatment%20Guide%20June%202018_mod_2021.pdf

O'Bryan, E. M., Kraemer, K. M., Johnson, A. L., McLeish, A. C., & McLaughlin, L. E. (2017). Examining the role of attentional control in terms of specific emotion regulation difficulties. *Personality and Individual Differences*, *108*, 158–163. https://doi.org/10.1016/j.paid.2016.12.015

Ofoe, L. C., Anderson, J. D., & Ntourou, K. (2018). Short-term memory, inhibition, and attention in developmental stuttering: A meta-analysis. *Journal of Speech, Language, and Hearing Research: JSLHR*, *61*(7), 1626–1648. https://doi.org/10.1044/2018_JSLHR-S-17-0372

Paap, K. (2019). The bilingual advantage debate. In *The handbook of the neuroscience of multilingualism* (pp. 701–735). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119387725.ch34

Paap, K. R., Myuz, H. A., Anders, R. T., Bockelman, M. F., Mikulinsky, R., & Sawi, O. M. (2017). No compelling evidence for a bilingual advantage in switching or that frequent language switching reduces switch cost. *Journal of Cognitive Psychology*, *29*(2), 89–112. https://doi.org/10.1080/20445911.2016.1248436

Packman, A., Onslow, M., Reilly, S., Attanasio, J., & Shenker, R. (2009). Stuttering and bilingualism. *Archives of Disease in Childhood*, *94*(3), 248–248.

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual Review of Neuroscience*, *35*(1), 73–89. https://doi.org/10.1146/annurev-neuro-062111-150525

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(1), 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Posner, M. I., & Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. *Annual Review of Psychology*, *58*(1), 1–23. https://doi.org/10.1146/annurev.psych.58.110405.085516

Riley, G. (2009). *Stuttering severity instrument for children and adults (SSI-4)* (4th ed.). Pro-Ed.

Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1996). The structure of normal human attention: The test of everyday attention. *Journal of the International Neuropsychological Society*, *2*(6), 525–534. https://doi.org/10.1017/S1355617700001697

Roelofs, A. (2008). Attention to spoken word planning: Chronometric and neuroimaging evidence. *Language and Linguistics Compass*, *2*(3), 389–405. https://doi.org/10.1111/j.1749-818X.2008.00060.x

Roelofs, A., & Piai, V. (2011). Attention demands of spoken word planning: A review. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00307

RStudio Team. (2022). *RStudio: Integrated development environment for R. RStudio* [Computer software]. PBC. http://www.rstudio.com/

Rueda, M. R., & Posner, M. I. (2013). Development of attention networks. In P. D. Zelazo (Ed.), *The oxford handbook of developmental psychology, Vol. 1: Body and Mind*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199958450.013.0024

Saad Merouwe, S., Bertram, R., Richa, S., & Eggers, K. (2022). Bilinguisme et bégaiement Revue de la littérature et discussion des implications cliniques. *Glossa 132*, 67–91.

Saad Merouwe, S., Bertram, R., Richa, S., & Eggers, K. (2023). Identification of stuttering in bilingual Lebanese children across two presentation modes. *Journal of Fluency Disorders*, *76*, 105970. https://doi.org/10.1016/j.jfludis.2023.105970

Singer, C. M., Walden, T. A., & Jones, R. M. (2020). Attention, speech-language dissociations, and stuttering chronicity. *American Journal of Speech-Language Pathology*, *29*(1), 157–167. https://doi.org/10.1044/2019_AJSLP-19-00039

Smith, A. (1999). Stuttering: A unified approach to a multifactorial, dynamic disorder. In N. B. Ratner & E. C. Healey (Eds.), *Stuttering research and practice: Bridging the gap* (pp. 27–44). Psychology Press.

Smith, A., & Weber, C. (2017). How stuttering develops: The multifactorial dynamic pathways theory. *Journal of Speech, Language, and Hearing Research: JSLHR*, *60*(9), 2483–2505. https://doi.org/10.1044/2017_JSLHR-S-16-0343

Suen, H. K., & Ary, D. (2014). *Analyzing quantitative behavioral observation data*. Psychology Press.

Tao, L., Marzecová, A., Taft, M., Asanowicz, D., & Wodniecka, Z. (2011). The efficiency of attentional networks in early and late bilinguals: The role of age of acquisition. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00123

Tendera, A. (2019). *Reactive and proactive response inhibition in neurodevelopmental stuttering* [Doctoral dissertation]. University of Alberta. https://doi.org/10.7939/r3-eb0d-em63

Travis, L. E., Johnson, W., & Shover, J. (1937). The relation of bilingualism to stuttering. *Journal of Speech Disorders*, *2*(3), 185–189. https://doi.org/10.1044/jshd.0203.185

Treffers-Daller, J., Ruigendijk, E., & Hofweber, J. (2021). Editorial: Behavioral and neurophysiological approaches to code-switching and language switching. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.660695

Treleaven, S. B., & Coalson, G. A. (2020). Manual response inhibition and quality of life in adults who stutter. *Journal of Communication Disorders*, *88*, 106053. https://doi.org/10.1016/j.jcomdis.2020.106053

Treleaven, S. B., & Coalson, G. A. (2021). Verbal response inhibition in adults who stutter. *Journal of Speech, Language, and Hearing Research: JSLHR*, *64*(9), 3382–3397. https://doi.org/10.1044/2021_JSLHR-20-00739

Tumanova, V., Conture, E. G., Lambert, E. W., & Walden, T. A. (2014). Speech disfluencies of preschool-age children who do and do not stutter. *Journal of Communication Disorders*, *49*, 25–41. https://doi.org/10.1016/j.jcomdis.2014.01.003

Van den Noort, M., Struys, E., Bosch, P., Jaswetz, L., Perriard, B., Yeo, S., Barisch, P., Vermeire, K., Lee, S.-H., & Lim, S. (2019). Does the bilingual advantage in cognitive control exist and if so, what are its modulating factors? A systematic review. *Behavioral Sciences*, *9*(3), 27. https://doi.org/10.3390/bs9030027

Ware, A. T., Kirkovski, M., & Lum, J. A. G. (2020). Meta-analysis reveals a bilingual advantage that is dependent on task and age. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01458

Werle, D. R., Byrd, C., & Coalson, G. (2020). Description of multilingual participants who stutter: An update 2011-2018. *Communication Disorders Quarterly*, *42*(1), 50–57. https://doi.org/10.1177/1525740119870772

Yairi, E., & Seery, C. H. (2023). *Stuttering: Foundations and clinical applications* (3rd ed.). Plural Publishing.

Yaruss, J. S., & Quesal, R. W. (2006). Overall assessment of the Speaker's experience of stuttering (OASES): Documenting multiple outcomes in stuttering treatment. *Journal of Fluency Disorders*, *31*(2), 90–115. https://doi.org/10.1016/j.jfludis.2006.02.002

Zelazo, P. D. (2020). Executive function and psychopathology: A neurodevelopmental perspective. *Annual Review of Clinical Psychology*, *16*(1), 431–454. https://doi.org/10.1146/annurev-clinpsy-072319-024242

Appendix

A language and social background questionnaire

1. General information

1.1 Age: ______________

1.2 Sex: F [ ] M [ ] Other [ ] NA(I'd prefer not to answer) [ ]

1.3 Country of birth: ______________

1.4 If you were not born in Belgium or the Netherlands, which year did you move to Belgium or the Netherlands? ____________ (year)

1.5 Current country of residence: Belgium [ ] The Netherlands [ ]
Other (Please specify) [ ] ____________

1.6 What is the highest level of education you have completed?
None [ ] Primary school [ ] Secondary school [ ] Vocational education and training(MBO) [ ]
BA[ ] MA [ ] PhD[ ]

1.7 What do you do professionally?
University student [ ] Employee/Self-employed [ ] Unemployed/Seeking employment
Other(Please specify) [ ] _______

1.8 Have you ever had a hearing impairment or speech and language disorder?
No [ ] Yes(Only stuttering) [ ]
Yes (If it is other than stuttering, please specify) [ ] ___________________________

1.9 Do you have a vision problem? No [ ] Yes(Please specify) [ ] ______________

1.10 What is your dominant hand? Right [ ] Left[ ]

2. Language History/Proficiency

2.1 Your first language(s): ____

2.2 List all languages you have learned & the age of first intensive contact *(if from birth, then write 0)*, and estimate your level for speaking, listening, reading & writing *(1=Beginner, 7=Native-like)*.

Language	Age	Speaking	Listening	Reading	Writing
		1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
		1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
		1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
		1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7
		1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

2.3 What language or languages did you use at home before age 4?

____

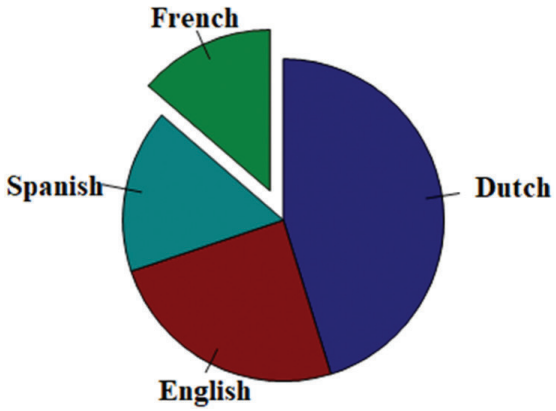
2.4 What language or languages do/did you use at university (if applicable)?

____

2.5 If you have taken any standardised language proficiency tests (e.g., TOEFL), then specify the name of the test, the language assessed, and the score you have obtained for each. If you do not remember the exact score, then write an "*Approximate score*" instead.

Test	Language	Score	Approximate Score

3. Language Function



3.1 Please indicate your **current** relative use of Dutch, English, and/or any other languages with percentages for the following activities like in the picture: For example: Dutch 45%, English 30%, French 13%, Spanish 12%

	Dutch	English	. . . . . (another language)	. . . . . (another language)	. . . . (another language)
Speaking	%	%	%	%	%
Listening	%	%	%	%	%
Reading	%	%	%	%	%
Writing	%	%	%	%	%

4. Language Mode (Code-Switching)

4.1 Some people switch languages within a single conversation (e.g., while speaking one language, they use words or even sentences from another language). This is known as "**Code-Switching**". Please indicate how often you code-switch in the following situations:

	Never	Rarely	Sometimes	Often	Always
With parents, family members (incl. partner)	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
On social media (Facebook, Twitter, Instagram) and gaming	☐	☐	☐	☐	☐

4.2 Please indicate how often you code-switch when talking about certain matters.

	Never	Rarely	Sometimes	Often	Always
When speaking about neutral matters	☐	☐	☐	☐	☐
When speaking about personal matters (something related to income or political conviction, or family business etc)	☐	☐	☐	☐	☐
When speaking about emotional matters (anything that gets the heart beat faster)	☐	☐	☐	☐	☐

5. Affective Variables

5.1 How anxious are you when speaking your different languages with different people in different situations?

	Never	Rarely	Sometimes	Often	Always
When speaking Dutch					
With family members	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
With colleagues	☐	☐	☐	☐	☐
With strangers	☐	☐	☐	☐	☐
On the phone	☐	☐	☐	☐	☐
In public	☐	☐	☐	☐	☐

	Never	Rarely	Sometimes	Often	Always
When speaking English					
With family members	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
With colleagues	☐	☐	☐	☐	☐
With strangers	☐	☐	☐	☐	☐
On the phone	☐	☐	☐	☐	☐
In public	☐	☐	☐	☐	☐

	Never	Rarely	Sometimes	Often	Always
When speaking another language (*If it is applicable*) (**Please also specify the language below!**)					
Language:					
With family members	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
With colleagues	☐	☐	☐	☐	☐
With strangers	☐	☐	☐	☐	☐
On the phone	☐	☐	☐	☐	☐
In public	☐	☐	☐	☐	☐

	Never	Rarely	Sometimes	Often	Always
When speaking another language (*If it is applicable*) (**Please also specify the language below!**)					
Language:					
With family members	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
With colleagues	☐	☐	☐	☐	☐
With strangers	☐	☐	☐	☐	☐
On the phone	☐	☐	☐	☐	☐
In public	☐	☐	☐	☐	☐

	Never	Rarely	Sometimes	Often	Always
When speaking another language (*If it is applicable*) (**Please also specify the language below!**)					
Language:					
With family members	☐	☐	☐	☐	☐
With friends	☐	☐	☐	☐	☐
With colleagues	☐	☐	☐	☐	☐
With strangers	☐	☐	☐	☐	☐
On the phone	☐	☐	☐	☐	☐
In public	☐	☐	☐	☐	☐