Investigating the presumed cognitive advantage of aspiring interpreters

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In complex tasks such as interpreting, the importance of a well-functioning working memory can hardly be overestimated. However, empirical studies have failed to produce consistent results with regard to an interpreter advantage in working memory. Recent studies tend to focus on the executive component of working memory. To our knowledge, no such study has compared the possible cognitive advantage of aspiring interpreters relative to other multilinguals before training takes place, in spite of the fact that excellent cognitive abilities are considered important in many interpreter selection procedures. In this study, we compared the working memory capacity and executive functions of a group of 20 student interpreters with two other groups of advanced language users who were all at the start of their Master's training. Data were collected on three executive control functions: inhibition, shifting and updating. A forward and a backward digit span task for measuring the participants' working memory capacity was also included in this study. Results revealed only negligible differences between the three groups at onset of training. The presumed cognitive advantage of aspiring interpreters with regard to executive control was not found.

Keywords: working memory, executive control, updating, inhibiting, switching

1. Introduction

Excellent memory skills have long been recognized as an important aspect of simultaneous interpreting (Alexieva 1993; Darò 1995; Gile 1999, 2009; Keiser 1965). In the literature various types of memory-related concepts are discussed, such as short-term memory, working memory, cognitive load, and memory effort. In this contribution we will focus on working memory. When we talk about working memory we refer to the hypothetical cognitive component that is responsible for

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temporarily holding and manipulating information. Working memory has been shown to play a crucial role in performing complex tasks such as language learning and language processing (Baddeley 1992, 2003). Baddeley's working memory model (Baddeley 2000, 2003; Baddeley & Hitch 1974), with its four subsystems, remains the most influential visualization of working memory to date: (1) the phonological loop, which is concerned with verbal and acoustic information, consists of a storage system and a subvocal rehearsal system; (2) the visuospatial sketchpad is its visual counterpart; (3) both are dependent on a higher-level control system, the central executive, which regulates the attentional control of working memory; and (4) the episodic buffer is a multi-dimensional storage system combining both visual and verbal information that heavily depends on the central executive and allows for the storage of information that exceeds the capacity of the phonological loop or the visuospatial sketchpad.

Working memory capacity is commonly measured through complex span tasks, such as a reading or listening span task. Up to now, most empirical studies on interpreters have focused on working memory capacity (e.g. Christoffels et al. 2006; Liu et al. 2004; Tzou et al. 2012). They tend to compare interpreters (including student interpreters) with non-interpreters, hypothesizing that professional interpreters will exhibit a larger working memory span. However, not all studies have shown this advantage in capacity in interpreters. The mixed research outcomes might indicate that working memory span is inadequate to assess differences in working memory. This places the role of the central executive or attentional control system in the foreground. Recently, research has started to focus on these central executive functions (e.g. Köpke & Nespoulous 2006; Morales et al. 2015; Timarová et al. 2014) as the possible locus of any memory-related differences between interpreters (including student interpreters) and non-interpreters. While no formal definition of executive functions has been put forward (Jurado & Rosselli 2007), we distinguish three executive functions as proposed by Miyake et al. (2000): updating, inhibiting and shifting.

In this study we aim to establish whether students who opt for the interpreting programme already have better developed cognitive skills than their peers who choose to become translators or multilingual communication specialists. To this end, we will compare the working memory of these three groups of advanced language learners. This comparison will allow us to corroborate the presumed cognitive advantage of interpreters, on which there is still a shortage of research (Obler 2012).

Among the three executive functions mentioned earlier, the updating function refers to the ability to compare new incoming information to information already held in memory (Morris & Jones 1990). In interpreting this seems to relate to the ability to handle a continuous stream of incoming speech while previous input is still being processed. Secondly, two types of inhibition were gauged. The first type is the resistance to interference, which involves the ability to suppress task-irrelevant information (Engle et al. 1999). Applied to the interpreting context, this refers to the ability to ignore distractors such as the sound of the interpreter's own voice and other sounds or visual disturbances during their performance (Timarová et al. 2014). The second type of inhibitory control is the resistance to automatic response (Miyake et al. 2000). For the interpreter this could translate, for example, into the resistance to use false cognates. The final executive function under investigation is shifting, which requires the ability to switch between separate tasks or mental sets (Miyake & Friedman 2012). This is relevant in interpreting because of the continual shift between processing incoming language and producing oral translations. In addition to the executive control measures we administered two digit span tasks to gauge both the storage and processing capacities of working memory.

2. Literature review

2.1 Cognitive abilities of bilinguals

According to the findings of quite a few studies, being a bilingual has a positive influence on one's cognitive abilities (e.g. Bialystok 2006; Costa et al. 2008). Bilinguals are known to have both of their languages active at all times (Van Assche et al. 2012) and they make few errors when they are required to switch from one language to the other, which means that an efficient cognitive control mechanism seems to be in place (Woumans et al. 2015). In a number of studies it has been suggested that this language control practice transfers to general cognitive control, resulting in a cognitive control advantage for bilinguals beyond the linguistic domain (e.g. Bialystok et al. 2004; Costa et al. 2009; Martin-Rhee & Bialystok 2008). These studies report that bilinguals often outperform their monolingual peers on executive tasks measuring different aspects of cognitive control (e.g. Bialystok et al. 2004; Luk et al. 2011). The advantage that these bilinguals display on these tasks is two-fold. Some studies have disclosed a general processing advantage, with faster reaction times on trials that do not elicit any conflict (i.e. 'congruent trials') (e.g. Bialystok 2006; Costa et al. 2008; Martin-Rhee & Bialystok 2008). Others have demonstrated superior conflict resolution skills in bilinguals, revealing smaller congruency effects (e.g. Bialystok et al. 2006; Costa et al. 2009). These effects are measured by calculating the difference in reaction times on congruent and incongruent trials.

Interestingly, different features of bilingualism seem to interact with the bilingual cognitive advantage. For instance, language switching frequency in daily life has been found to interact with the cognitive advantage, with frequent switchers performing better on cognitive control tasks (Verreyt et al. 2015).

2.2 Cognitive abilities of translators

Within the field of translation studies, working memory research has focussed on interpreters rather than translators. Only a handful of studies focus on translators' working memory capacity. Rothe-Neves (2003) investigated the influence of working memory on translation performance in an attempt to unravel the cognitive processes during translation tasks. He used verbal tasks adapted from Salthouse and Babcock's (1991) BAMT-UFMG test battery to compare processing speed, coordination and storage capacity between novice translators and professional translators. No differences between the working memory measures of the two groups were found. It has to be noted that only six students and six professionals took part in this study and that the average age difference between both groups was slightly more than ten years. As working memory deteriorates with age (Park et al. 2002), but increases with experience (Klingberg 2009), it is difficult to dissociate the influence of age and experience in this limited participant group.

Another study on working memory and translation, albeit not in a professional translator context, examines the role of working memory in error-making. Michael, Tokowicz, Degani and Smith (2011) investigate whether working memory and the ability to ignore task-irrelevant information – i.e. inhibition – is related to the ability to resolve translation ambiguity, which occurs when a word has multiple translations. The results show that the best translation tasks could be ascribed to those students who obtained the highest scores on the working memory capacity and inhibition tests.

2.3 Cognitive abilities of interpreters

Empirical studies on working memory in interpreting have typically used span tasks to measure working memory capacity. A number of these studies have found differences in working memory capacity between different groups (i.e. student or professional interpreters and bilingual controls). For example, Christoffels et al. (2006) compared the working memory capacity of trained interpreters with that of bilingual university students and highly proficient English teachers. The interpreters outperformed the students and the English teachers on a reading span task, a speaking span task and a word span task. Signorelli (2008) used the same tasks in a comparison of professional interpreters and bilingual non-interpreters, and found the interpreters to outperform the control group. Similarly, Tzou et al. (2012) compared the performance of two groups of interpreter students (i.e. first-year and second-year students) on a reading span task with that of bilingual controls. Not only did both student groups outperform the control group, but a positive correlation between high memory span and simultaneous interpreting performance was also established.

In contrast, a number of studies did not find differences in working memory capacity between different (student) interpreter groups. Chincotta and Underwood (1998), for example, did not establish a working memory advantage in a digit span task with articulatory suppression in a population of student interpreters and bilingual controls. Similarly, Köpke and Nespoulous (2006) did not find differences between novice interpreters, professional interpreters and bilingual controls in a listening span task and a recall task with articulatory suppression. The only difference found was on the listening span task, in which the novice interpreters outperformed the control groups, while the professional interpreters did not. In the same vein, Liu et al. (2004) found no difference in scores on a listening span test of professional interpreters and student interpreters, although the professionals did perform better on an interpreting task. They attributed the interpreters' better performance to their superior ability to select more important ideas from the speech input under highly demanding conditions.

Recently, researchers have directed their attention to the central executive component of working memory. Timarová et al. (2014), for instance, examined the executive functions of professional interpreters. Significant positive correlations were established between lexical processing and updating and shifting, and between ear-voice span scores and shifting, indicating that interpreters who maintained a short ear-voice span were faster shifters. A positive correlation was also established between accuracy in interpreting and an arrow flanker task, used to measure inhibition. Likewise, Morales et al. (2015) investigated the link between interpreting and updating, on the one hand, and interpreting and inhibition, on the other. They found professional interpreters to be more accurate and faster than bilingual controls in terms of updating capacities but not in terms of conflict resolution (i.e. inhibition).

In the study presented below, we will focus on working memory span and executive control prior to interpreter training. The main research question is whether a group of advanced language learners consisting of aspiring interpreters, translators and multilingual communicators show differences in both the storage and executive control components of working memory before they are trained in their respective domains. If interpreter students demonstrate superior cognitive control at the start of their training, then the interpreter advantage suggested in the literature cannot be attributed entirely to training or experience in interpreting.

3. Experiment

3.1 Research questions

1. Do student interpreters exhibit larger working memory capacity than student translators and student multilingual communicators prior to their respective training?
2. Do student interpreters exhibit better inhibition skills than student translators and student multilingual communicators prior to their respective training?
3. Do student interpreters exhibit better updating skills than student translators and student multilingual communicators prior to their respective training?
4. Do student interpreters exhibit better shifting skills than student translators and student multilingual communicators prior to their respective training?

3.2 Method

3.2.1 *Participants*

A total of 62 students enrolled at the Department of Translation, Interpreting and Communication of Ghent University took part in this study. All participants were native Dutch speakers studying two foreign languages. Their age ranged between 20 and 28 years, with a mean age of 21.8 years. The participants had all completed a Bachelor's degree in applied language studies and had just begun their vocational training in either a Master's in interpreting ($n = 21$), a Master's in translation ($n = 20$) or a Master's in multilingual communication ($n = 21$). The Master in Translation and the Master in Interpreting are both well-known and established programmes. The Master in Multilingual Communication is quite a recent programme focussing on high-level proficiency in the mother tongue and special skills in intercultural communication.

Although there is no admission test for the Master's programme in interpreting, students' previous training in the intensive bachelor programme as well as careful scouting of students mean that the process is not one of self-selection. The preceding Bachelor's programme is focussed on the practical use of two foreign languages, with an emphasis on oral proficiency and translation from and into the foreign languages, and on flawless spoken and written Dutch as a mother tongue. Over the course of this three-year training, about 60% of students fail or drop out at some stage of the programme. Only students with near-native competence in their foreign languages who show an interest in interpreter training and whose potential for interpreting has been confirmed by interpreting trainers, are invited to enroll. Others are dissuaded from taking up interpreting.

3.2.2 *Materials and procedure*

Data collection took place in September and October of the academic year 2014–2015. Participants were informed about the content and the length of the test battery and were asked to sign an informed consent form. Before each test, participants received oral explanations in their native language of what they were expected to do. For the computer-based tasks, the instructions also appeared in print on the screen, again in their native language. Computer tasks were presented via Tscope software (Simon task; Stevens et al. 2006) or E-prime software (Attention Network Test, 2-back task and colour-shape switch task) on an IBM-compatible laptop computer with a 15-inch screen, running XP. Participants were tested individually in a quiet room by a research assistant who remained present during the entire procedure, which took an hour on average. The order of tasks was counterbalanced across participants to avoid a fatigue effect.

Participants performed two types of tasks: (a) two digit span tasks (forward and backward) for measuring working memory capacity (Wechsler 1997) and (b) four tasks tapping into executive control functions: a 2-back task (Kirchner 1958), a Simon task (Simon & Rudell 1967), the Attention Network Test (Fan et al. 2002) and a colour-shape switch task (Rogers & Monsell 1995). These tasks were selected on the basis of their widespread use in working memory research. Both reaction time and accuracy rate were recorded and used in the analyses.

Digit span tasks

Both forward and backward spans were measured. The forward span task measures storage capacity, whereas the backward span task requires executive control (Engle et al. 1999). The tasks were adapted from the WAIS-III (Wechsler 1997) and consisted of 16 sequences of digits of increasing length (from two to nine) in the forward condition and 14 sequences in the backward condition. Each trial comprised two sequences of the same length. In the forward span task, participants were read a sequence of digits and asked to orally recall the digits in the same order. In the backward span task, they were asked to recall the digits in reverse order, which requires manipulation of the incoming information. The task ended when all sequences had been read or when the participants made errors in both sequences of the same length.

Simon task

A coloured Simon task was used to assess participants' ability to inhibit automatic responses. Green and red dots appeared on either the left or the right side of the screen and participants were asked to press the left key when one colour appeared, and the right key when the other colour appeared. The combination of position and colour constituted either a congruent trial or an incongruent trial.

The experiment consisted of ten randomised practice trials and two blocks of 100 randomised experimental trials. Half of all trials presented the coloured dot on the same side of the associated response key, and half on the opposite side.

Attention Network Test

A shortened version of the Attention Network Test (ANT) was employed. The ANT measures the *executive network* (for conflict resolution, i.e. the inhibition function) and the *orienting network* (for sensory input selection). The experimental design contained two within-subject factors: flanker type (congruent and incongruent) and cue type (none, central and spatial). Comparing congruent and incongruent trials measured the executive network, and comparing central and spatial cue trials quantified the orienting network. Participants were shown five arrows and were asked to indicate the direction of the middle arrow. Participants were instructed to focus on the fixation cross and respond as quickly and accurately as possible. They pressed the left button of a touchpad when the target pointed to the left, and the right button of that touchpad when the target pointed to the right.

Colour-shape switch task

This task was used to assess task *shifting* or *switching* abilities. It consisted of two blocked conditions and a switch condition. In the colour block condition, participants were asked to respond to the colour of an image, and in the shape block condition, they were asked to respond to its shape. The switch condition required participants to respond to either shape or colour, depending on the cue.

In this task we are particularly interested in how well participants cope with the possibility of having to switch between tasks. This is called the Mix Cost and is calculated by subtracting overall scores in the blocked condition, where there is no possibility of switching, from stay trial scores in the switch condition, where the possibility of having to switch exists but is not utilized. In addition, we also want to know how well they coped with actually having to switch. This is labelled the Switch Cost and is calculated by subtracting switch trial scores from stay trial scores in the switch condition.

2-back task

The 2-back task was employed as a measure of *updating* skill. It consisted of 25 black-and-white line drawings of daily objects that provide high naming agreement in Dutch, based on the norming study by Severens, Lommel, Ratinckx and Hartsuiker (2005). Drawings were presented individually and were centred on the computer screen. Participants were required to indicate as fast and as accurately as possible whether a presented item matched the one presented two positions before by pressing the left key (i.e. mismatch) or the right key (i.e. match) on the keyboard. Besides match trials (i.e. the target item matched the picture two positions before) and mismatch trials (i.e. the target item did not match the pictures two positions before), there were also a number of lure trials in which the target item matched the item three positions back.

3.3 Results

The demographics of the participant population of multilingual communicators (MC), translators (TRANS) and interpreters (INT) are presented in Table 1.

Table 1. Demographic information on the three groups

	MC	TRANS	INT	Test	*p*
N	21	20	21		
Male/female ratio	2/19	5/15	6/15	$\text{Chi}^2(2) = 2.59$	.274
Age (in years)	21.9 (2.5)	22.1 (1.4)	22.1 (2.1)	$F_{2,59} < 1.0$	.904

Note: Standard deviations appear in parentheses.

3.3.1 *Digit span tasks*

For the measurement of participants' storage and processing capacity, both the forward and backward span tasks were taken into account and the span effect (i.e. the difference between the scores on the forward span and the backward span tasks) was calculated. A small span effect does not necessary equal better working memory. For example, if a participant obtained a very high score on the forward span task and a moderately high score on the backward span task, this person would have a larger span effect than someone who received low scores on both tasks. Therefore, the span effect merely provides an indication of the impact of the more difficult condition (i.e. the backward span) on the participant's performance. The highest achievable score for the forward span task is 16, for the backward span task the maximum score is 14. The scores for the three groups can be found in Table 2. Levene's test indicated that equal variances could be assumed for span effect ($F(2,58) = .026$, $p = .974$) but not for forward span scores ($F(2,58) = .722$, $p = .490$) or backward span scores ($F(2,58) = 4.624$, $p = .014$).

Table 2. Digit span scores for the three groups

Test	MC	TRANS	INT
Forward	10.0 (1.6)	10.5 (1.5)	10.0 (1.9)
Backward	7.2 (2.1)	6.5 (1.2)	7.6 (2.1)
Effect	2.8 (1.7)	4.0 (1.9)	2.4 (1.8)

Note: Standard deviations appear in parentheses.

Span analyses by means of a 3 (Group: MC, TRANS, INT) × 2 (Span: Forward, Backward) ANOVA yielded a main effect of Span ($F_{1,58} = 173.93$, $p < .001$, $\eta_p^2 = .750$), with higher scores on forward spans than on backward spans. This fits the generally accepted assumption that backward span tasks are more challenging. There was no main effect of Group ($F_{2,51} < 1.0$, $p = .796$, $\eta_p^2 = .008$), but there was a Span*Group interaction ($F_{2,51} = 4.08$, $p = .022$, $\eta_p^2 = .123$). Planned comparisons demonstrated a significant difference between the group of translators and the group of multilingual communicators ($t_{58} = 2.12$, $p = .039$) and between the group of translators and the group of interpreters ($t_{58} = 2.73$, $p = .008$). In both cases, the group of translators had a larger span effect. As these populations had comparable scores on the forward span task, the difference in span effect was caused by a poorer performance of the translator group on the backward span task. This means that the interpreter group and the multilingual communicator group were less affected by the more difficult backward condition than the translator group.

3.3.2 *Executive control tasks*

With regard to the four executive control tasks, analyses were performed on mean reaction times (RT) and accuracy percentages (ACC). For each task, outlier RTs were trimmed for individual participants by calculating the mean across all trials and excluding any response deviating by more than 2.5 *SD* of that mean. This procedure eliminated 3.1% of all Simon data, 2.1% of all ANT data, 3.8% of all colour-shape switch data, and 3.6% of all 2-back data. Due to a technical problem, Simon and Switch scores were not recorded for one student translator and two student interpreters. To determine differences between groups on any of the tasks, repeated measure ANOVAs with Group as the independent variable and subsequent planned comparisons (where necessary) were carried out. All task data are presented in Table 3.

Table 3. Executive control task results for the three groups

Test	MC	TRANS	INT
Simon			
RT			
Congruent	406 (57)	395 (48)	378 (46)
Incongruent	438 (60)	421 (41)	410 (48)
Congruency effect	32 (21)	26 (22)	33 (11)
ACC			
Congruent	98.1 (1.8)	97.9 (2.1)	96.9 (2.2)
Incongruent	96.1 (2.5)	95.6 (3.8)	93.6 (5.0)

Table 3. *(continued)*

Test	MC	TRANS	INT
Congruency effect	1.9 (2.5)	2.3 (3.7)	3.3 (4.4)
ANT			
RT			
Congruent	510 (58)	487 (51)	491 (60)
Incongruent	608 (67)	575 (66)	581 (75)
Congruency effect	98 (42)	88 (27)	90 (28)
Orienting effect	60 (26)	63 (16)	59 (21)
ACC			
Congruent	99.5 (0.8)	99.3 (1.4)	99.5 (0.7)
Incongruent	94.8 (5.4)	95.1 (5.4)	93.9 (6.8)
Congruency effect	4.7 (5.3)	4.2 (5.4)	5.6 (6.8)
Orienting effect	1.7 (3.0)	1.9 (5.5)	2.7 (5.5)
Colour-shape Switch			
RT			
Mix Cost	165 (126)	182 (119)	210 (155)
Switch Cost	164 (112)	132 (97)	127 (119)
ACC			
Mix Cost	5.1 (4.5)	6.5 (12.5)	6.7 (12.0)
Switch Cost	2.6 (6.4)	5.4 (6.6)	2.4 (4.7)
2-back			
RT			
Match	728 (131)	730 (176)	748 (177)
Mismatch	672 (84)	686 (85)	714 (142)
Lure	813 (190)	882 (196)	877 (225)
ACC			
Match	95.4 (14.6)	98.6 (1.4)	95.4 (14.6)
Mismatch	83.5 (14.4)	81.6 (17.6)	83.5 (14.4)
Lure	70.3 (16.7)	70.8 (17.8)	70.3 (16.7)

Note: Reaction times (RT) are given in milliseconds and accuracy (ACC) in percentages. Standard deviations appear in parentheses.

3.3.3 *Simon task*

The data of three participants from the multilingual communicator group were not analysed, because their accuracy scores were all 0.0%, probably because they had pressed the wrong keys.

A 3 (Group: MC, TRANS, INT) × 2 (Congruency: Congruent, Incongruent) ANOVA on RTs showed a main effect of Congruency ($F_{1,51} = 138.61$, $p < .001$, $\eta_p^2 = .731$), with faster responses to congruent trials, which is customary in this type of task. The main effect of Group ($F_{2,51} = 1.37$, $p = .261$, $\eta_p^2 = .051$) and the Congruency*Group interaction ($F_{2,51} < 1.0$, $p = .447$, $\eta_p^2 = .031$) were not significant. In other words, all groups had similar RTs and similar Simon effects.

The same ANOVA was run on accuracy scores and yielded a main effect of Congruency ($F_{1,51} = 25.01$, $p < .001$, $\eta_p^2 = .329$), with higher accuracy rates on congruent trials, which is considered normal. The main effect of Group was not significant ($F_{2,51} = 2.57$, $p = .087$, $\eta_p^2 = .092$), nor was the Congruency*Group interaction ($F_{2,51} < 1.0$, $p = .527$, $\eta_p^2 = .025$).

Attention Network Test

RTs were analysed via a 3 (Group: MC, TRANS, INT) × 2 (Congruency: Congruent, Incongruent) × 3 (Cue: None, Centre, Spatial) ANOVA. This provided a main effect of Congruency ($F_{1,59} = 487.69$, $p < .001$, $\eta_p^2 = .892$) and Cue ($F_{2,58} = 331.18$, $p < .001$, $\eta_p^2 = .919$), but not of Group ($F_{2,59} = 1.28$, $p = .285$, $\eta_p^2 = .042$). RTs were faster for congruent trials as opposed to incongruent trials, and RTs were also faster when a spatial cue was present and were slowest on trials with no cue. Congruency or Cue never interacted with the effect of interest, namely Group (all ps > .350). Hence, there was no Group effect for orienting.

The ACC analysis was almost identical, with a main effect of Congruency ($F_{1,59} = 41.69$, $p < .001$, $\eta_p^2 = .414$) and Cue ($F_{2,58} = 5.95$, $p = .004$, $\eta_p^2 = .170$), but no effect of Group ($F_{2,59} < 1.0$, $p = .857$, $\eta_p^2 = .005$). ACC was higher for congruent trials, and the accuracy rate was also higher when a spatial cue was present. Again, Congruency or Cue never interacted with Group (all ps > .610): no effect for orienting was found.

3.3.4 *Colour-shape switch task*

The data of two participants from the translator group were not analysed, because their accuracy scores were around 0.0–1.0%, probably due to pressing the wrong keys.

For RTs, the 3 (Group: MC, TRANS, INT) × 1 (Mix Cost or Switch Cost) ANOVAs yielded no differences between groups for either Mix Cost ($F_{2,54} < 1.0$, $p = .582$) or Switch Cost (($F_{2,54} < 1.0$, $p = .528$).

For accuracy, analyses were the same and produced similar results (Mix Cost: $F_{2,54} < 1.0$, $p = .873$; Switch Cost: $F_{2,54} = 1.49$, $p = .235$). In other words, the three groups performed similarly, both in terms of response times and accuracy rates.

3.3.5 *2-back task*

For the RT analysis, a 3 (Group: MC, TRANS, INT) × 3 (Condition: Match, Mismatch, Lure) ANOVA was carried out. There was a main effect of Condition ($F_{2,58} = 38.70$, $p < .001$, $\eta_p^2 = .572$), with the fastest RTs for mismatch trials and the slowest for lure trials. There was, however, no effect of Group and no interaction with Group (both Fs < 1.0, ps > .541).

ACC analyses demonstrated a main effect of Condition ($F_{2,58} = 139.09$, $p < .001$, $\eta_p^2 = .827$), with the highest ACC for match trials and the lowest for lure trials, which is the standard effect of load. Again, there was no effect of or interaction with Group (both Fs < 1.0, ps > .883). In other words, there was no significant difference between the performances of the three groups.

4. Discussion

In the following discussion of the results, the findings will be related to those that have been reported in the literature. However, as no comparative study of pre-training differences between interpreter students and other language majors has yet been conducted, we are limited to comparing our findings with those of studies contrasting student interpreters, professional interpreters and bilingual controls.

In answer to the first research question, which looks into the working memory capacity of the three participant groups, the interpreter group and the multilingual communicator group had the smaller span effect, which in this case means that the backward condition was less challenging for them than for the translator group. In other words, when only storage capacity is measured (forward span task), the three groups perform equally well, but when executive control is required in combination with this storage capacity, the student interpreters and student multilingual communicators perform significantly better than the translators. This points to a small cognitive advantage for the student interpreters compared to the student translators, and they seem to share this advantage with the students of multilingual communication. This may be explained by the nature of the task: the listening and speaking components of the digit span tasks are probably better aligned with the competences of students who opt for vocational training with a strong oral component.

Regarding the second research question, concerning an interpreter advantage for the inhibition function, the analysis of the data showed no significant differences between the three populations: not for the ability to suppress automatic responses as measured by the Simon task, nor for the ability to ignore irrelevant stimuli, measured by the ANT. This could indicate that inhibition is a skill acquired through interpreting practice, which is supported by the fact that Timarová et al. (2014) found a higher degree of inhibition skills in older and consequently more experienced interpreters.

The third research question concerned a comparison of updating skills between student interpreters, student translators and students of multilingual communication. There is no significant difference in updating abilities as measured by the colour-shape switch task between the three groups. The assumption that our student interpreters would do better than their peers when it comes to monitoring incoming information and replacing previous information with new information has to be discarded. Differences in updating performances between professional interpreters and bilingual controls or between professional interpreters and student interpreters found in other studies might be the effect of training and experience. Some support for this claim can be found in the study of Morales et al. (2015), who found that expertise in interpreting enhances updating skills.

The fourth research question looked into the shifting abilities of the three participant groups. The ability to switch attention between two different tasks is part and parcel of an interpreter's performance, which is why student interpreters learn to do so during their training. However, prior to interpreter training no difference between the shifting abilities of student interpreters and student translators and students of multilingual communication was found. Other studies, such as Yudes et al. (2011), found superior shifting abilities in professional interpreters compared to bilinguals with comparably high memory span. Again, we can only assume that the absence of better shifting abilities in our interpreting students points to the fact that shifting skills are developed during training.

In summary, we can state that the results of the various tests are not indicative of differences in executive control between the three populations we tested. A sensitivity analysis using G*Power (Faul et al. 2009) was conducted in order to gauge the possible lack of power of our results as a consequence of the modest number of participants in each group. It revealed that a study with our design and sample sizes has 70% power to detect true effects of size .35, assuming normality, equal variances and a 5% significance level.

5. Conclusion

The aim of this study was to compare the cognitive abilities of aspiring interpreters to those of other language majors prior to training. While a number of studies have found better working memory capacity (e.g. Christoffels et al. 2006;

Signorelli 2008; Tzou et al. 2012) or superior executive control (e.g. Morales et al. 2015; Yudes et al. 2011) in interpreters (including student interpreters) as compared to bilinguals, to our knowledge, no study has yet examined novices at the beginning of training. Therefore, these studies have been unable to ascertain whether the so-called interpreter advantage is an effect of interpreter training. While there is some recent evidence that interpreter training induces changes in brain structure (Hervais-Adelman et al. 2015), the possibility that superior cognitive ability is already present prior to interpreter training cannot be discarded. After all, executive functions are among the most heritable psychological traits (Friedman et al. 2008). Since it is generally assumed that people tend to choose a profession that suits their cognitive skills (Turner & Bowen 1999), the interpreter profession might be more appealing to those with better developed executive control. It is against this backdrop that we have compared student interpreters with student translators and student multilingual communicators before they started their vocational training.

The results of the study show that only the backward digit span task, which combines storage and executive control, differentiated between the three participant groups. We can only assume that the oral aspect of the backward span task (an aspect which was not present in the computerized tasks) played an important role. The two groups of students who had chosen a training programme with a strong oral component (interpreting and multilingual communication) outperformed the student group with a preference for written language (translation).

With a view to interpreter training, we believe that the absence of reliable differences between interpreting students and other language students in terms of executive control prior to training suggests caution in the use of cognitive tests when screening potential interpreting students. The general assumption of excellent working memory skills being a prerequisite for interpreter training and the tradition of including an assessment of memory skills in entrance examinations for interpreters (Timarová & Ungoed-Thomas 2008) may need to be reconsidered.

Limitations of the present study include the limited number of participants (but see our earlier remark on statistical power) and the fact that the selected executive control tasks traditionally use visual stimuli. The overreliance on visual input might have biased the results vis-à-vis the cognitive style preference of participants. Also, as one reviewer of this paper pointed out, the students who participated in the study may not have succeeded in completing their Master's programme and can therefore not be considered suitable representatives of the three groups of language majors. However, at the time of the definitive re-submission of this paper, the three participant groups had all completed their respective training programmes and received their degrees. By means of a follow-up study in which the student interpreters are re-tested on the same battery of tests after completing their training, we plan to investigate the effect of interpreter training on student interpreters' executive control functions.

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