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Individual differences in the production of referential expressions: The effect of language proficiency, language exposure and executive function in bilingual and monolingual children

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Review

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3 Referential choice in bilingual and monolingual children
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7 Individual Differences in the Production of Referential Expressions:
8 The Effect of Language Proficiency, Language Exposure and Executive Function in
9 Bilingual and Monolingual Children*

10
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13

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Abstract

One hundred and seventy-two English-speaking 5- to 7-year-olds participated in a referential communication task where we manipulated the linguistic mention and the visual presence of a competitor alongside a target referent. Eighty-seven of the children were additionally exposed to a language other than English (bilinguals). We measured children's language proficiency, verbal working memory (WM), cognitive control skills, family SES, and relative amount of cumulative exposure and use of the home language for the bilinguals. Children's use of full Noun Phrases (NPs) to identify a target referent was predicted by the visual presence of a competitor more than by its linguistic mention. Verbal WM and proficiency predicted NP use, while cognitive control skills predicted both the ability to use expressions signalling discourse integration and sensitivity to the presence of a discourse competitor, but not of a visual competitor. Bilingual children were as informative as monolingual children once proficiency was controlled for.

Keywords: referential choice, anaphora, individual differences, cognitive control, gradient bilingualism

Introduction

One of the core aspects of human communication revolves around the choice of linguistic expressions for referent identification, i.e. the use of proper names (e.g. *Laura*), Noun Phrases – NPs - (e.g. *the girl, my sister, my sister's car*) and pronouns (e.g. *she, them, someone*) to talk about entities in the world. Adults, and, to some extent, preschool and school-age children are sensitive to a number of structural, semantic and discourse-pragmatic constraints when it comes to producing referential expressions in a communicative context (see Serratrice & Allen, 2015, for an overview of the acquisition of reference).

Despite a general sensitivity to the aforementioned constraints, there are individual differences in the extent to which both adults and children rely on perspective-taking skills to process and produce referential expressions. Taking the perspective of a conversational partner requires the inhibition of one's own perspective and the shifting to that of the addressee. Recent work on adult speakers (Ryskin, Benjamin, Tullis & Brown-Schmidt, 2015; Wardlow, 2013), and some emerging work in child and adolescent speakers (Nilsen & Graham, 2009; Nilsen, Varghese, Xu & Fecica, 2015; Torregrossa, 2017; Wardlow & Heyman, 2016), has identified executive function skills, particularly working memory (WM), and cognitive control, i.e. the ability to resolve a conflict by inhibiting an irrelevant response and promoting relevant information, as significant predictors of individual variation in referential communication success. The use of a referential expression implies a choice, for example a pronoun vs. a NP. This choice arises from the selection between different options and, at least in some cases, it is the outcome of the resolution of a conflict between competing alternatives. For example, if the speaker

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3 and the addressee have different levels of access to a target referent, their mental
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5 representations will not entirely overlap. The onus is on the speaker to inhibit a
6
7 potentially egocentric perspective and promote an addressee-friendly perspective that
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9 will maximise the chances of convergence between the mental representations of both
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11 speaker and addressee. This can translate into choosing a more informative NP (e.g.
12
13 *the tall girl*), as opposed to a more reduced and less informative expression (e.g. *she*).
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15 Because conflict monitoring and resolution depend on the inhibition of irrelevant
16
17 information, the promotion of relevant information, or both, we will adopt the term
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19 cognitive control to include both the inhibition and the promotion aspects of the
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21 process (Teubner-Rhodes, Mishler, Corbett, Andreu, Sanz-Torrent, Trueswell &
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23 Novick, 2016).
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27 WM refers to the ability to store and manipulate information, and it has been
28
29 connected to perspective-taking and referential choice in at least two ways. Firstly, it
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31 underpins the storage and updating of the interlocutor's perspective and the
32
33 comparison of that perspective with one's own to check for convergence (Nilsen &
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35 Bacso, 2017; Wardlow, 2013). Secondly, it may be implicated in the use of feedback
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37 in the case in which one of the interlocutors explicitly signals a mismatch between
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39 their perspective and that of their conversational partner. Higher verbal WM capacity
40
41 has been shown to correlate positively with 5- and 6-year-olds ability to use an adult's
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43 non- verbal feedback to produce a discourse-appropriate referential expression
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45 (Wardlow & Heyman, 2016).
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50 A parallel line of research has singled out bilingual speakers – both older
51
52 adults and children - as having an advantage in the same executive function skills of
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54 cognitive control that are associated with referential choice (Bialystok & Martin,
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56 2004; Morales, Calvo & Bialystok, 2013). Whether bilinguals genuinely have
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3 superior WM skills compared to monolinguals, or not, is, however, not yet clear.
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5 Some studies report no difference between bilingual and monolingual children
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7 (Barbosa, Jiang & Nicoladis, 2017; Bialystok, Luk, and Kwan 2005; Engel de Abreu,
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9 2011), others report an advantage for bilingual children (Morales, Calvo, & Bialystok,
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11 2013).
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15 In the present study we combine these two independent lines of inquiry to
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17 investigate how degrees of exposure to/and use of English and another home
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19 language, language proficiency in English, and executive function skills (cognitive
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21 control and verbal WM), predict the choice of linguistic expressions in a referential
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23 communication task in monolingual and bilingual children between the ages of 5 and
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25 7. In the task we manipulated a linguistic factor (the discourse mention of a
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27 competitor to the target referent) and a non-linguistic factor (the visual presence of a
28
29 competitor to the target referent) to provide new evidence on the sources of contextual
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31 information used by children in reference production. Previous work has focused on
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33 children's use of deictic expressions in referential communication tasks (e.g. Nilsen &
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35 Graham, 2009), while we were specifically interested in children's use of anaphoric
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37 expressions to refer to a previously mentioned antecedent.
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41 Research including bilingual children has sometimes neglected to take into
42
43 account the SES profile of participants. This is an important limitation as SES is
44
45 known to be predictive of both language and of cognitive skills. In the present study
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47 we therefore included a measure of SES in our analyses.
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49 ***Constraints on referential choice***

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51 Adult speakers are sensitive to a number of structural and discourse-pragmatic
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53 constraints in their referential choices. They tend to use more pronouns for referents
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55 that are in subject position (Arnold, 2001) and/or in sentence-initial position
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3 (Järvikivi, van Gompel, Hyönä & Bertram, 2005), or for referents that are topics
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5 (Anderson, Garrod & Sanford, 1983). Conversely, competent speakers tend to use
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7 more informative referential expressions (e.g. proper names and indefinite NPs) when
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9 the referent is new to the discourse (Gordon, Hendrick, Ledoux & Yang, 1999), or
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11 when the use of a pronoun might lead to potential ambiguity (Arnold, 2008). Adult
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13 speakers generally can take the perspective of their listener into account, and they
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15 choose their referential expressions accordingly. Perspective-taking is predicated
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17 upon the ability to distinguish between what is in the common ground (Clark, 1992),
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19 and therefore shared knowledge between speaker and listener, and what is in the
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21 privileged ground, i.e. knowledge that is only accessible to the speaker. The common
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23 ground can either be established perceptually, i.e. when it includes referents that are
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25 visually accessible to both interlocutors, and/or it can be established linguistically via
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27 the use of discourse-appropriate referential expressions.
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31 Competent adult speakers typically engage in modelling their addressee's
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33 perspective to produce a referential expression that is optimal for their conversational
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35 partner (Hendriks, Englert, Wubs & Hoeks, 2008). In essence the assumption is that
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37 competent speakers maintain their own mental representation of their addressee's
38
39 mental representation. However, the extent to which these meta-representations
40
41 always require an effortful and intentional commitment on the part of the speaker, and
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43 whether they necessarily rely on explicit Theory of Mind skills, is debated in the
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45 literature (Horton & Brennan, 2016).
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49 Even before they have a fully developed Theory of Mind, three-year-olds are
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51 already at least partly sensitive to the same constraints that regulate referential choice
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53 in adult speakers (see Allen, Hughes & Skarabela, 2015, for a review). Pre-school
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55 children are more likely to omit arguments, or use reduced expressions, when they are
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3 part of the common ground either through joint attention (Skarabela, 2007), previous
4 linguistic mention (Allen & Schröder, 2003; Clancy, 2003; Guerriero, Oshima-
5 Takane & Kuriyama, 2006; Stephens, 2015), or prior mention and/or perceptual
6 availability (Campbell, Brooks & Tomasello, 2000; De Cat, 2011; Matthews, Lieven,
7 Theakston & Tomasello, 2006; Rozendaal & Baker, 2010; Salazar Orvig et al., 2010a;
8 Salazar Orvig et al., 2010b).

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16 At the same time, children are notoriously less capable than adults when it
17 comes to taking their listener's perspective into account and to adjusting their
18 referential choices accordingly. This has been observed in production studies in pre-
19 schoolers (De Cat, 2011, 2015), in five-year-olds (Theakston, 2012), and in six-years-
20 old (Serratrice, 2008) when children need to provide a referential expression, and up
21 to adolescence in comprehension where participants need to make a choice between
22 potential referents (Dumontheil, Apperly, & Blakemore, 2010).

23 24 25 26 27 28 29 30 31 ***Individual variation in perspective-taking skills: cognitive control and verbal WM***

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33 It is becoming increasingly apparent that there are individual differences in the
34 degree of perspective-taking abilities, and that this variation may correlate with the
35 ability to interpret referential expressions in discourse-pragmatic appropriate ways
36 (Brown-Schmidt, 2009; Lin, Keysar & Epley, 2010; Ryskin et al., 2015). Studies on
37 adults have focused on the relationship between perspective-taking abilities - indexed
38 by referential choice - and cognitive control and WM - two core components of
39 executive function. There is some additional evidence that cognitive control also
40 plays a role in perspective-taking and referential interpretation in pre-school children.
41 In two referential communication studies with three- and five-year-olds, Nilsen and
42 Graham (2009) reported that performance on a cognitive control task significantly
43 predicted comprehension accuracy for both the younger and the older children.
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3 However neither WM nor cognitive control were predictive of accuracy in a
4 production task in which the five-year-olds had to provide a disambiguating adjective
5 to identify a referent in the privileged ground condition. Nilsen and Graham (2009)
6 speculated that this non-significant finding could be due to the fact that their measure
7 for assessing children's perspective taking (i.e. the number of adjectives in the
8 common ground condition) was not sufficiently sensitive to reveal the impact of
9 cognitive control.
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18 Some of the adult studies point to a positive correlation between cognitive
19 control skills and perspective-taking abilities in the online interpretation (Brown-
20 Schmidt, 2009; Lin et al., 2010) and production of referential expressions (Wardlow,
21 2013), but others have failed to replicate this finding with monolingual and bilingual
22 adults in a spatial perspective-taking task (Ryskin, Brown-Schmidt Canseco-
23 Gonzalez, Yiu, & Nguyen, 2014), and with children with ADHD in a referential
24 communication task (Nilsen, Mangal & Macdonald, 2013).
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33 Verbal WM (WM) has also been recently linked to individual differences in
34 perspective-taking skills in the production of referential expressions in monolingual
35 adults (Wardlow, 2013). Referential choice requires the speaker to focus on those
36 conceptual features that make the target different from potential competitors that may
37 or may not be accessible to the addressee. This evaluation process relies on the
38 storage in memory of the features of the target and it additionally requires a
39 comparison with the features of the competitors. This is a complex set of operations
40 that involve both the storage and the manipulation of information. In essence these
41 demands are comparable to those of a WM task where the information must be
42 retained in memory while being subjected to additional operations. Adopting a
43 computational modelling approach, Hendriks (2016) has argued for individual
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3 differences in WM capacity and processing speed as predictors of informativity in
4 referential choice. Hendriks (2016) reports on a series of computational simulations
5 where the manipulation of WM capacity in the network led to significant differences
6 in the use of pronouns vs. NPs to refer back to a potentially ambiguous antecedent
7 (van Rij, 2012). In the low WM model there was a significantly higher proportion of
8 underspecified and underinformative pronouns than in the high WM model where
9 more pragmatically adequate NPs were used.
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18 The role of verbal WM has not yet been explored in connection with
19 referential choice in bilingual children. In monolingual children, Nilsen and Graham
20 (2009) did not find WM to be predictive, possibly because of the relatively low task
21 demands, but Wardlow and Heyman (2016) found it to be positively correlated with
22 5- and 6-year-olds' ability to benefit from adult non-verbal feedback in a referential
23 production task. Children with higher WM improved their use of discourse-
24 appropriate referential expressions in the course of the experiment when they received
25 feedback that they were being uninformative. In a sample of monolingual German-
26 speaking 8- to 10-year-olds Torregrossa (2017) also found a positive correlation
27 between WM - indexed by backward-digit-span scores - and the discourse-
28 appropriate use of demonstrative pronouns in a story-telling task pronouns. In the
29 light of Wardlow's (2013) preliminary findings with adult speakers, Torregrossa's
30 (2017) findings with 8- to 10-year-olds, and the results in the feedback condition for
31 the 5- and 6-year-olds in Wardlow and Heyman's (2016) study, it is theoretically
32 interesting to test whether the relationship between choice of referring expressions
33 and verbal WM generalizes to bilingual child speakers
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52 ***The role of language experience, language proficiency, and SES***

53 A parallel but independent line of research has shown, albeit not
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3 uncontroversially (see Valian, 2015), that cognitive control is one area in which
4
5 bilinguals may have an advantage over monolinguals (Bialystok, 2015). If bilingual
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7 children do have an advantage when it comes to inhibiting information that is in their
8
9 privileged ground and promoting information in the common ground, and if this kind
10
11 of cognitive control is conducive to referential communication, it follows that
12
13 bilingual children should, in principle, be more successful in choosing discourse-
14
15 appropriate linguistic expressions in a referential communication task that requires
16
17 cognitive control. To date no studies have directly investigated whether individual
18
19 differences in cognitive control and WM confer an advantage to young bilinguals
20
21 when it comes specifically to referential choice. The literature on referential
22
23 expressions in bilingual children and adults has principally focused on the issue of
24
25 cross-linguistic influence, and on whether the interpretation of third person pronouns
26
27 is affected in a null-subject language when the other language has obligatory overt
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29 subjects (Serratrice & Hervé, 2015). More recently some studies with infants and
30
31 young children have reported a bilingual advantage for sensitivity to referential cues
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33 (Fan, Liberman, Keysar, & Kinzler, 2015; Liberman, Woodward, Keysar, & Kinzler,
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35 2017)

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39 Although superior cognitive control skills may put bilingual children in a
40
41 privileged position in terms of perspective-taking and referential choice, other factors
42
43 must also be considered as predictors of discourse-appropriate linguistic choices. The
44
45 bilingual language experience is, by its very nature, distributed across language, and –
46
47 at least in relative terms - bilingual children receive proportionally less input in each
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49 language that monolingual children. Although relative amount of exposure is only an
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51 indirect and imperfect approximation of input quantity (Carroll, 2017; De Houwer,
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53 2014; Hurtado, Grüter, Marchman & Fernald, 2014), it has repeatedly been shown to
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3 correlate robustly with measures of language proficiency (Hoff, Welsh, Place &
4 Ribot, 2014; Unsworth, 2013).

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7 It is plausible to expect a positive correlation between overall language skills
8 and the ability to select discourse-appropriate referring expressions. Hence, whatever
9 advantage superior cognitive control skills might confer to bilinguals when it comes
10 to referential choice – if any – it may be offset by lower language proficiency when
11 compared to monolingual children. Ryskin et al. (2014) make a similar claim to
12 account for the lack of a bilingual advantage in a spatial perspective-taking task with
13 adults. Some evidence that language proficiency may play a role comes from a
14 referential communication study (Fan, Liberman, Keysar, & Kinzler, 2015) which
15 also included measures of language proficiency (receptive vocabulary), cognitive
16 control, and fluid intelligence, in a group of monolingual 5-year-olds and two groups
17 of age-matched children who were either bilingual, or exposed to a multilingual
18 environment. The only significant effect was that of group with both the bilingual and
19 multilingual exposure children outperforming the monolinguals. Crucially the three
20 groups did not differ in terms of receptive vocabulary, and therefore it remains to be
21 seen whether bilinguals with lower language skills than monolinguals might be
22 adversely affected in a linguistic task.
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41 Another variable that may potentially affect children's linguistic and cognitive
42 performance is SES. SES is a complex construct and it is considered a proxy for
43 access to a range of economic, educational and occupational resources (Hauser &
44 Warren, 1997; McLoyd, 1998). Although there is a vast and expanding literature on
45 the relationship between SES and language and cognitive development, attributing a
46 causal role to SES in child development is not straightforward because SES is a
47 multifaceted notion and so are language and cognition (Duncan & Magnuson, 2012).
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3 For example, SES has been shown to affect vocabulary size but not utterance length
4 (Hoff-Ginsberg, 1998), grammar but not pragmatic development (Wells, 1986), and
5 the effects are greater for expressive than receptive vocabulary (Snow, 1999).
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9 In monolinguals the complex relationship between linguistic and cognitive
10 development and SES is well documented (Hackman & Farah, 2009; Hackman,
11 Gallop, Evans & Farah, 2015). When it comes to bilingual children, there is inevitably
12 an added layer of complexity. In bilingual populations SES also has a predictive role
13 on language and cognitive skills, although it is not often easy to tease apart the
14 relative contribution of bilingualism and SES. In many studies there are significant
15 cultural differences between the bilingual and the monolingual groups, and the
16 immigrant status of the bilinguals may present an additional confound. A number of
17 studies have recently tried to disentangle SES from bilingualism (Calvo & Bialystok,
18 2014; Carlson & Meltzoff, 2008) and the main finding seems to be that both
19 bilingualism and SES independently account for the variance observed in linguistic
20 and cognitive tasks. The relationship between SES, bilingualism, and language and
21 cognitive performance is however complex (Gathercole, Kennedy & Thomas, 2015)
22 and is mediated by language exposure, age and the specific aspect of language (e.g.
23 vocabulary vs. grammar), or of non-verbal cognition being tested.
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44 **The present study**

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46 To date, the relationship between perspective-taking skills, cognitive control,
47 verbal WM, and referential choice has mostly been studied in the context of online
48 comprehension. Studies investigating the predictive role of executive function skills
49 in production have reported mixed results (Nilsen & Graham, 2009; Wardlow Lane,
50 2013; Ryskin et al., 2015; Torregrossa, 2017; Wardlow & Heyman, 2016).
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3 The first aim of the present study is to test whether cognitive control, as
4 measured by the Simon task, and verbal WM, as measured by backward digit recall,
5 are predictive of referential choice in a production task in which child participants
6 need to build a complex situation model and identify a target referent in settings in
7 which we manipulate the presence of discourse and visual competitors. The prediction
8 is that the Simon task score and the backward digit recall score will correlate
9 positively with the informativeness of the participants' referential choices.
10
11 The second aim of the present study is to investigate the contribution of language
12 experience to perspective-taking abilities and referential choice. English-speaking
13 monolingual children and bilingual children with varying degrees of exposure to a
14 language other than English (henceforth the *home language*) are therefore included in
15 the study. Language experience is conceptualized here both in terms of cumulative
16 amount of exposure and use of the home language (Bilingual Profile Index, BPI, De
17 Cat, Gusnanto & Serratrice, 2017; De Cat & Serratrice, under review), and in terms of
18 language proficiency as measured by the Articles sub-test of the Diagnostic
19 Evaluation of Language Variation (Seymour, Roeper & de Villiers, 2003), a dialect-
20 neutral assessment for 4- to 9-year-olds, that minimizes the effects of language
21 exposure differences in bilingual and bicultural children. We expect that children with
22 better language proficiency – which is in turn likely to be predicted by the amount of
23 exposure and use of English – will be more sensitive to the presence of discourse and
24 visual competitors. It is also conceivable that language experience and language
25 proficiency would interact, such that bilingual children might display an advantage
26 only if their English proficiency falls within the range of their monolingual
27 counterparts – as shown by Fan et al. (2015).
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54 Finally, studies of perspective-taking skills have typically investigated the
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3 comprehension and use of NPs containing disambiguating size or colour adjectives
4 (e.g. *the small duck, the red square*) that directly pick out an entity in a visual display
5 and are therefore not anaphoric (e.g. Nilsen & Graham, 2009; Wardlow & Heyman,
6 2016). In contrast, in the present study we are focusing on the use of anaphoric
7 expressions, i.e. third person pronouns vs. NPs, and on how the discourse and visual
8 contexts determine the choice of a referential expression for a target referent in the
9 presence of one or two antecedents that may be either visually present, linguistically
10 mentioned, both, or neither.
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20 The experiment is modelled on the studies in Fukumura, van Gompel and
21 Pickering (2010) with monolingual adult participants where they manipulated the
22 linguistic mention and the visual presence of a competitor to a target referent.
23 Although Fukumura et al. (2010) did not address this issue, the use of an NP in
24 conditions in which a pronoun is ambiguous should – at least partly – be predicted by
25 cognitive control and verbal WM. Those participants that are more successful at
26 inhibiting their egocentric perspective, and have better WM resources to deal with a
27 complex scene, should be those that are sensitive to the presence of a discourse and
28 visual referent that is in competition with the target.
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40 Our prediction is that, if - similarly to adults – children are sensitive to both
41 the linguistic and the non-linguistic features of the context in creating a discourse
42 model, they will produce more informative referential expressions, i.e. full NPs (e.g.
43 *the princess, the cowboy*) when the competitor is previously mentioned and when it is
44 visually present.
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50 SES will be included as a predictor in the analyses alongside measures of
51 language proficiency, language exposure and use, cognitive control and verbal WM,
52 to assess the contribution that these child-internal factors might make to the use of
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3 anaphoric expressions in a demanding language production task.
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6 7 **Methods**

8 9 *Participants*

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11 After receiving ethical approval for the study by the University Research Ethics
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13 Committee of the second author's institution, children were recruited in state primary
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15 schools in the North of England. The final sample included 172 children attending
16
17 year 1 or year 2 of primary school (between the ages of 5 and 7), all of whom were
18
19 schooled exclusively in English. Half of the children (N = 87) were also exposed to a
20
21 language other than English at home; these children will be referred to as bilinguals.
22
23 In this study we adopted a broad definition of bilingualism that reflects the typical
24
25 situation of many classrooms in the UK where children are classified as learners of
26
27 English as an Additional Language (EAL) if 'a first language, where it is other than
28
29 English, is recorded where a child was exposed to the language during early
30
31 development and continues to be exposed to this language in the home or in the
32
33 community.' (DfE School Census Guide 2016-2017, p.63). Because of this
34
35 inclusionary criterion, the children in our bilingual group had a wide range of
36
37 exposure (as low as 9%) to 28 different home languages: Punjabi (21% of bilingual
38
39 participants), Urdu (17%), Arabic (9%), French (8%), Spanish (6%), Bengali,
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41 Cantonese, Catalan, Dutch, Farsi, Greek, Hindi, Italian, Kurdish, Mandarin, Marathi,
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43 Mirpuri, Nepalese, Pashto, Polish, Portuguese, Shona, Somali, Swedish, Tamil,
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45 Telugu, Thai, Tigrinya (languages with no percentage indicator accounted for less
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47 than 5% of the sample). Our bilingual group was therefore deliberately heterogeneous
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49 to capture the variability of children who are currently considered as bilingual (EAL
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3 learners) in multilingual classrooms in the UK, and to capitalise on the notion of
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5 bilingualism as a continuous measure.
6

7 *Measures*

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9 In addition to the main referential communication task that is the object of this
10
11 study, we collected information on the children's SES, on their exposure and use of
12
13 English and the home language, and tested their proficiency in English, their verbal
14
15 WM and their cognitive control skills.
16

17
18 *Socio-economic Status (SES)*. The children came from schools in a range of
19
20 different catchment areas to ensure variation in SES. We collected information on
21
22 parental education and occupation via questionnaires. Children were allocated an SES
23
24 score on the basis of the highest level of occupation or education in the household
25
26 (either mother or father). Education was coded on a five-point scale (none, primary,
27
28 secondary, further, university), and the occupational data was coded according to the
29
30 reduced method of the UK National Statistics socio-economic classification. We used
31
32 the reversed occupational data scores to make the interpretation of the association
33
34 with the educational level data more transparent, so that a higher value represents an
35
36 advantage. As expected there was a strong association between the two measures (χ^2
37
38 (4, N = 174) = 83.57, $p < 0.0001$). We also found a weak but significant negative
39
40 correlation between level of bilingualism as measured by the children's cumulative
41
42 amount of exposure and use measured by the Bilingual Profile Index - as described
43
44 below- and SES as measured by parental occupation ($r = -.25$, $p = 0.0009$).
45
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48
49 *Language exposure and use*. We used a parental questionnaire to estimate the
50
51 bilingual children's relative amount of exposure and use of English and of the home
52
53 language. The questionnaire, which includes both current and cumulative estimates of
54
55 the amount of exposure and use, is modelled on the BiLEC (Unsworth, 2013). The
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3 parents (usually the mother) completed the questionnaire in English, Bengali, Punjabi
4
5 or Urdu with the help of a bilingual assistant. They were asked to quantify the amount
6
7 of their child's current exposure and use of the two languages on a typical school day,
8
9 at weekends, and during holiday periods. School days were divided into slots of one
10
11 hour before and after school during which children were exposed predominantly to
12
13 English. It is possible that children may have used the home language with some
14
15 same-language peers at school but because parents – and not teachers – were asked to
16
17 complete the questionnaire, we did not have access to this information and we
18
19 conservatively assumed that during school hours children only heard and used
20
21 English. Parents were asked about all of the child's interlocutors, and to estimate on a
22
23 five-point scale how often they addressed the child in the home language (never,
24
25 rarely, half of the time, usually, always). We later converted the scores into discrete
26
27 percentage bands ranging from 0 (never) to 100% (always). Parents were also asked
28
29 to recall age of first exposure to English. To calculate the current relative amount of
30
31 exposure to English and the home language for a given child we extrapolated the
32
33 number of hours that the child spends with each interlocutor on a yearly basis, and we
34
35 multiplied this figure for the percentage of time the child used either English or the
36
37 home language with each interlocutor. The percentages for each of the child's
38
39 interlocutors were added and then divided by the total number of hours of interaction
40
41 pooled for all interlocutors, if several interlocutors were present at the same time, the
42
43 estimate was divided by the number of interlocutors for the relevant time window.
44
45 The resulting was a percentage expressing the relative amount of input for English
46
47 and the home language. We applied the same method to the calculation of a relative
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49 measure of child's output, i.e. use of English or the home language. For the
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51 cumulative amount of input/output in each language we firstly calculated the number
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3 of months of home language use only, i.e. before children were exposed to English –
4 this was 0 for the simultaneous bilingual children – we then multiplied the number of
5 months of bilingual exposure by the proportion of current input/output. The resulting
6 figure is the total number of months equivalent to full-time exposure to the home
7 language.
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13 The use of parental questionnaires to collect information on quantity and
14 quality of child-directed input has obvious limitations and has lately come under
15 critical scrutiny (Carroll, 2017). Although we acknowledge the constraints of this data
16 collection method, we are also confident that it is a pragmatic solution whose validity
17 and robustness have been repeatedly confirmed (De Houwer, 2017; Paradis, 2017).
18
19

20 Current and cumulative measures of input and output in the home language
21 were highly correlated in our sample (current input and output: $r = .90, p < 0.0001$;
22 cumulative input and output: $r = .95, p < 0.0001$). Because we wanted to use both
23 dimensions of the language experience as predictors in our analysis but needed to
24 avoid collinearity for modelling purposes, we used Principal Component Analysis
25 (PCA) to decorrelate the two measures and create a composite score of cumulative
26 input and output which we call the Bilingual Profile Index (BPI, De Cat et al., 2017;
27 De Cat & Serratrice, under review). The PCA of cumulative input and cumulative
28 output yielded two principal components, the first of which captured 98% of the
29 variability (given the strength of the correlation between the two cumulative
30 measures). The BPI scores correspond to the loadings of that first component,
31 reversed (so that a higher score corresponds to more experience in the home
32 language) and aligned with a score of 0 for monolinguals. The BPI can be interpreted
33 as a cumulative and gradient measure of a bilingual child's experience of their home
34 language, effectively close to the number of full-time months of exposure corrected
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3 for any imbalance between exposure and use. The range of the BPI in our sample is
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5 from 0 to 96.

6
7 *Language proficiency.* We used the Articles sub-test of the Diagnostic
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9 Evaluation of Language Variation - DELV (Seymour et al., 2003) as a measure of
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11 language proficiency in English, the language of schooling. The DELV is a language
12
13 assessment of syntax, semantics, pragmatics and phonology for children between the
14
15 ages of 4 and 9. This test was specifically developed to neutralize dialectal differences
16
17 and it focuses on language structures that are common to all children from English-
18
19 speaking backgrounds regardless of the particular variety of English they speak. We
20
21 chose the Articles sub-test as an independent measure of language proficiency as it
22
23 taps into some of the same discourse-pragmatic skills that are required for the
24
25 appropriate use of referential expressions.¹
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29 *Verbal working memory (WM).* We used the Backward Digit Span task from
30
31 the Wechsler Intelligence Scales for Children (Wechsler, 1991) as a proxy measure
32
33 for children's verbal WM capacity. The backward digit span was administered
34
35 according to the WISC-III^{UK} instructions: for each digit span the experimenter
36
37 administered two trials, regardless of whether the first trial was passed or failed, and
38
39 discontinued the test after failure on both trials of any item. Backward digit recall is
40
41 one of three complex memory span measures (the other two being listening recall and
42
43 counting recall) that in a confirmatory analysis were shown to load onto one single
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47 ¹ Performance in this proficiency task is significantly correlated with performance on
48
49 other language proficiency measures collected as part of our larger study including
50
51 the School-Age Sentence Imitation Task (Marinis, Chiat, Armon-Lotem, Gibbons &
52
53 Gipps, 2010). See De Cat & Serratrice (under review, <https://osf.io/wkgv7/>) for
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55 details.
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3 factor by Gathercole, Pickering, Ambridge and Wearing (2004). Unlike forward digit
4 recall, which only requires the storage and immediate recall of a sequence of spoken
5 items and taps into the phonological loop, backward digit recall implies both the
6 phonological loop, for the storage of items, and the central executive, for the
7 additional processing in the reversing of the digits.
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13 *Cognitive control.* Children were administered a computer-based version of
14 the Simon task (Simon & Wolf, 1963) programmed and run via E-Prime. The Simon
15 task is considered a complex response inhibition task (Garon, Bryson & Smith, 2008).
16 because it involves moderate WM demands in addition to the inhibition of a prepotent
17 response. Participants need to hold a rule in mind (press the left button when you see
18 x, press the right button when you see y), respond according to this rule (physically
19 press the key), inhibit a prepotent response when the rule changes and respond
20 accordingly (press left button when you see y, press the right button when you see x).
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31 The Simon task is one of many complex inhibition tasks that have been used
32 in the developmental literature to measure children's ability to inhibit a prepotent
33 response while responding to a salient conflicting response option (see Garon et al.,
34 2008 for a comprehensive review). With specific reference to the bilingual-
35 monolingual comparison, previous studies have shown that bilingual children
36 outperform monolingual peers only in tasks that assess the interference suppression
37 component of cognitive control (Bialystok & Shapero, 2005; Qu, Low, Zhang, Li &
38 Zelazo, 2016), but not in tasks that assess response inhibition alone (Martin-Rhee &
39 Bialystok, 2008).
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50 Children sat in front of a 15.6" computer screen and used an E-Prime serial
51 response button box with colour-coded buttons (red on the left and green on the right).
52 Children started with 8 practice trials followed by 48 test trials; there was no neutral
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3 condition in which the coloured square would appear in the middle of the screen.
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5 Accuracy and Reaction Times (RTs) were automatically recorded by E-Prime. The
6
7 index of cognitive control abilities used as a predictor in the present study
8
9 corresponds to the modelled score in the Simon task, i.e. children's score adjusted for
10
11 age, SES, bilingual experience (indexed by the BPI), and accuracy at the previous
12
13 trial.² These correspond to the significant predictors of a Cox Proportional Hazard
14
15 regression analysis, as reported in detail in De Cat et al. (2017). The Cox PH model
16
17 captures response accuracy and speed within the same analysis, so the resulting score
18
19 combines both aspects of children's performance.
20

21
22 Table 1 provide descriptive statistics for the monolingual and bilingual groups:
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24
25 Insert Table 1 here
26

27 ***Materials and experimental design***

28
29 Following the design of the studies in Fukumura et al. (2010), the experiment
30
31 manipulated the visual presence and the linguistic mention of a competitor to a target
32
33 referent in a 2x2 design in four conditions: competitor present and mentioned,
34
35 competitor present and not mentioned, competitor absent and mentioned, competitor
36
37 absent and not mentioned. There were five items in each of the four conditions and
38
39 ten filler items. Each experimental item consisted of a set of two coloured
40
41 photographs of iconic Playmobil characters (e.g. fireman, cowboy, ghost, queen),
42
43 while the fillers included coloured geometric shapes and animals. Both the first and
44
45 the second photograph in the experimental set always included the target referent (e.g.
46
47 a fireman). In the *competitor present* conditions another referent of the same gender
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53 ² The modelled score was obtained using the predict function of the survival package
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55 in R (version 2.38.3), which was used for the analysis.
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3 also appeared in both photographs (e.g. a fireman and a pirate). Half of experimental
4
5 items contained characters of feminine gender, and the position of the target and the
6
7 competitor was counterbalanced throughout the experiment.
8

9 See Figures 1 and 2 for examples of experimental items in the competitor
10
11 visually present or absent conditions, and the Appendix for a full set of experimental
12
13 and filler items.
14

15
16 Insert Figure 1 and Figure 2 here
17

18 The first photograph in each set was presented alongside a digitally recorded
19
20 sentence spoken by a female native speaker of Northern British English. The sentence
21
22 was a passive whose subject contained a genitive phrase where the possessor was the
23
24 animate target referent and the possessum was an inanimate entity (e.g. *The fireman's*
25
26 *bed has been made*). In the conditions in which the competitor was mentioned it
27
28 appeared in the passive's *by*-phrase (e.g. *The fireman's bed has been made by a*
29
30 *pirate*).
31
32

33 The rationale for embedding the target referent as the possessor in a genitive
34
35 phrase (e.g. *The fireman* in *The fireman's bed*) was to reduce its accessibility and thus
36
37 generally decrease the likelihood that participants would only ever use pronouns in
38
39 their continuation. It also allowed us to tease apart sentence-initial position from
40
41 topichood. Like Fukumura et al. (2010) we also wanted to ensure that the bias
42
43 towards using a pronoun for a highly salient subject antecedent would not completely
44
45 obliterate the role of the visual context. The photographs were embedded in a
46
47 PowerPoint presentation. The second picture appeared after the first had disappeared
48
49 off the screen and was accompanied by the pre-recorded prompt "*And now...*".
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51

52 **Procedure**

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54 The children were tested on school premises. Two female experimenters took
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3 part in the task; experimenter A sat next to the participant; the participant sat in front
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5 of a laptop computer and the two were separated by a divider so they could not see
6
7 what the other was looking at but they could see each other. Experimenter B
8
9 introduced the task to the participant as a communication game and explained that the
10
11 aim was to give instructions to experimenter A so that she could re-create the scenes
12
13 in the child's pictures with the toys that she was given by experimenter B.
14
15
16 Experimenter B pressed the space bar on the child's laptop on each trial to start the
17
18 experiment and to move on to the next item. Before the experiment started there were
19
20 two practice trials with feedback. No children had to be discarded for not
21
22 understanding the task. At the start of each trial experimenter B pressed the space bar
23
24 and the first picture appeared on the computer screen accompanied by the pre-
25
26 recorded linguistic description (e.g., "*The fireman's bucket has been filled (by a*
27
28 *musician)*") lasting an average of 4000 ms. The space bar was pressed again at the
29
30 end of the sentence and the target picture would appear accompanied by the prompt
31
32 "*And now...*". This was the participant's cue to start giving directions to experimenter
33
34 A to arrange the toys to recreate the scene that the child would describe (e.g. *And now*
35
36 *the fireman/he/the man is carrying the bucket*). Experimenter A had the same toys
37
38 that were present in the child's picture. When the participant had completed their
39
40 instruction they looked round the divider to see whether the experimenter's toy
41
42 arrangement matched the photograph on their computer screen. The experimenter
43
44 remained in their seat, they showed the participant their toys and asked "*Like that?*".
45
46
47 Whenever the participant used an under-informative pronoun, experimenter A always
48
49 chose the competitor to give the participant indirect feedback about their level of
50
51 underinformativity.
52
53

54 55 ***Transcription and scoring*** 56 57

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3 Participants' instructions to experimenter A were digitally recorded and
4 transcribed using CHAT for CHILDES (MacWhinney, 2000); utterances were later
5 imported into Excel and coded for the following features: mention of target referent
6 (1= target referent; 0 = competitor); label used (repeated name from the preamble
7 sentence, e.g. *the king*; an alternative label in the same semantic field– e.g. *the prince*
8 instead of *the king*; an alternative label that only matched the referent in gender, e.g.
9 *the man* instead of *the king*, *the lady* instead of *the dentist*); discourse integration (1=
10 pronouns and definite NPs anaphorically referring to the target referent- e.g.
11 *he/she/the queen*; 0 = indefinite pronouns – e.g. *somebody* – and indefinite NPs – e.g.
12 *a man* - that do not make clear anaphoric reference to the target).

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14
15 The “discourse integration” coding operates a binary distinction between
16 anaphoric and non-anaphoric expressions; the “label used” coding provides a more
17 fine-grained distinction within different types of anaphoric referential expressions.
18 While *the king*, *the prince*, *the man* are all definite NPs, they vary along a continuum
19 of disambiguating information. We deliberately chose stereotypical and easily
20 identifiable referents for the experimental items (i.e. king, fireman, astronaut, queen,
21 nurse, etc.). To be maximally informative in the task, participants should ideally have
22 used the label that was provided in the preamble description associated with the first
23 photograph in the experimental pair. Using a different and less informative label
24 might lead to potential ambiguity that would, in turn, increase as a function of the
25 label's lack of informativeness. So, in the case of a label in the same semantic field
26 (e.g. *prince* instead of *king*) the likelihood of ambiguity would not be as high as in the
27 case of a highly underspecified definite NP like *the man* that would give experimenter
28 A only a vague cue to select the appropriate target toy to reconstruct the scene, and
29 would be just as underinformative as a third person or an indefinite pronoun.
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Results

Table 2 provides descriptive statistics for the results of the DELV Articles sub-test (language proficiency), the backward digit recall task (verbal WM) and the Simon task (cognitive control) for the monolingual and the bilingual groups. Note that the scales are different for the three measures. For the DELV, it is accuracy proportion from 0 to 1; for the backward digit recall it is the number of accurately recalled digits from 0 to 4 (as a score), and for the Simon task it is an index of cognitive control adjusted for age, SES, bilingual experience and accuracy at the previous trial; negative scores indicate better cognitive control skills.

Insert Table 2 here

A linear regression model fitted using the lme4 package (version 1.1.11) in R (version 3.2.4) to the overall score in the DELV Articles sub-test showed that performance was negatively correlated with the BPI ($t(168) = -2.90$; $p = 0.004$); as expected, bilingual children performed more poorly than monolinguals overall, greater exposure and use of the home language was correlated with lower proficiency scores. There was no significant effect of the BPI in the verbal WM task ($t(181) = -0.29$; $p = 0.77$). For the Simon task the results of a Cox-P Regression model showed a near-significant effect of group ($X^2(1) = 3.8$, $p = 0.05$) and a significant effect of home language experience over and above the effect of group, as the BPI was a positive predictor ($X^2(1) = 12.13$, $p = 0.0005$). There was however no significant interaction between bilingualism and cue congruency, and hence no Simon effect in the strict sense (in line with previous studies).

We conducted three analyses to address the role of cognitive control, verbal WM, cumulative home language exposure and use, SES, and language proficiency on

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2
3 the children's use of referential expressions. In the first analysis, following Fukumura
4 et al. (2010), our DV only included exact repetitions of the target referent named in
5 the context sentence vs. the use of third person pronouns. Two further analyses were
6 necessary to capture the broader picture. In the second analysis, we included all
7 referential expressions that made anaphoric reference to the target and investigated
8 their informativeness by creating a binary DV: (1) underinformative expressions:
9 third person singular pronouns (e.g. *he/she*) and underinformative definite NPs – e.g.
10 *the man* instead of *the king*, *the lady* instead of *the queen*; and (2) definite NPs that
11 were either exact repetition of the definite NP in the preamble sentence, or
12 semantically related labels (e.g. *the prince* instead of *the king*, *the singer* instead of
13 *the musician*).

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The third analysis identifies the factors that predict lack of discourse
integration. We used a two-way distinction between indefinites signalling a lack of
anaphoric discourse integration (i.e. indefinite NPs and indefinite pronouns), and
pronouns and definite NPs that made anaphoric reference to the target.

We fitted generalized linear mixed models using the lme4 package (version
1.1.15) in R (version 3.4.4). The models were fitted incrementally by adding
predictors one by one and retaining them only if they improved the model fit, yielding
a significant reduction in AIC and a significant R-squared value, with model
comparison estimated by likelihood ratio tests (Baayen, 2008). In each of the three
analyses we treated item as a random factor, participant was not included as random
factor because it would compete with the fixed factors capturing participant-related
variables such as the BPI, SES or proficiency. We tested for the significance of the
following fixed factors: the presence/absence of a discourse or a visual competitor,
the Simon task score (cognitive control), the backward digit recall score adjusted for

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3 age and proficiency (verbal WM), the DELV Articles sub-test score (language
4 proficiency), the BPI score (cumulative home language use and exposure), the SES
5 score, and age (in months). Age and Simon task scores were centered to facilitate the
6 interpretation of the models. The following interactions were also tested in all
7 analyses: visual competitor x discourse competitor (yielding the 4 experimental
8 conditions), discourse competitor x each participant-related predictor (BPI, SES, WM,
9 cognitive control), visual competitor x each participant-related predictor (BPI, SES,
10 WM, cognitive control), BPI x SES, BPI x proficiency, WM x proficiency. Gender
11 was added as a covariate. Age correlated strongly with other participant-related
12 predictors and could therefore not be included in the models without resulting in lack
13 of convergence. In the following we report the optimal models.

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27 To be consistent with the protocol in Fukumura et al. (2010) we excluded
28 references to the competitor. The total amount of data points expected, given the
29 number of participants (172) and items (20) was 3440, there were 66 no response
30 therefore the actual number was 3374. We excluded the following data from all
31 analyses: 86 items were excluded because of reference to the competitor, or
32 because the utterance was (partly) unintelligible. We also excluded a problematic
33 experimental item (N = 115) for a total of 201 items, i.e. 6% of the data.

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42 In the first analysis, the repeated name was expected to feature as the subject
43 in the first sentence that participants produced to describe the second picture in the
44 experimental item. As in Fukumura et al. (2010) we excluded a further 155 tokens
45 where the target referent was indefinite or lacked a determiner, as well as 310 tokens
46 that were not exact repetitions of the named referent. Altogether, 19% of the data was
47 excluded from the first analysis. The remaining responses included a total of 1766
48 NPs and 942 pronouns.

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3 The dependent variable was the likelihood of producing a definite NP (as
4 opposed to a pronoun) to identify the target referent in the second picture of the
5 experimental items. We used logistic regression to model the probability (in terms of
6 logits) associated with the values of the dependent variable. NP use was predicted
7 by the visual presence of a competitor ($z = 3.21, p < .001$), and there was a negative
8 correlation between the BPI and NP use ($z = -3.47, p < .001$) showing that bilingual
9 children with more exposure to the home language produced fewer NPs. There was a
10 significant interaction between the Simon task score and the presence of a discourse
11 competitor ($z = 2.09, p < .05$) indicating that sensitivity to the presence of a discourse
12 competitor was positively associated with better cognitive control skills. The
13 interaction between WM and language proficiency was also significant ($z = 8.39, p <$
14 0.001); children with better WM capacity and better proficiency produced more NPs.
15 The model did not converge with the addition of age as a continuous predictor.
16 Including a binary predictor for age (5- and 6-year-olds) resulted in a
17 significantly worse model fit in this and in all subsequent analyses.

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Insert Figure 3 and Figure 4 here

To investigate whether there was indeed a trade-off between language
proficiency and language experience that may disadvantage bilingual children we
compared the use of NPs in bilingual and monolingual children who performed above
and below the monolingual mean on the DELV. In this additional analysis visual
presence of a competitor remained significant ($z = 3.19, p < .001$), and so was the
main effect of verbal WM ($z = 3.93, p < .0001$). Language experience and language
proficiency were significant predictors. Monolingual children as a group used more
NPs ($z = 3.35, p < .001$) and all children with language proficiency above the mean
also used more NPs ($z = 9.35, p < .001$). There was a significant interaction between

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2
3 the Simon task score and the presence of a discourse competitor ($z = 2.12, p = .03$).
4
5 Further, there was an interaction between language experience
6
7 (monolingual/bilingual) and language proficiency (below/above the monolingual
8
9 mean) ($z = -2.15, p = .03$) whereby monolingual children below the language
10
11 proficiency mean used more NPs than bilingual children below the language
12
13 proficiency mean. For children above the language proficiency mean there was no
14
15 difference as a function of language experience as shown in Figure 5.
16

17
18 Insert Figure 5 here
19

20 As children used NPs other than the repeated name in their story continuation,
21
22 in a second set of logistic regression analyses, we investigated the level of
23
24 informativity of the label used to identify the target referent. The dependent variable
25
26 included all the referential expressions that children used to identify a target referent
27
28 where there was evidence of an attempt at discourse integration; we therefore
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30 excluded all bare nouns, indefinite NPs and indefinite pronouns (155 items), with
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32 8.3% of data excluded in total. The dependent variable was binary and had two
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34 levels: (1) underinformative expressions - third person singular pronouns and less
35
36 informative definite NPs (e.g. *the man; the lady*), and (2) more informative definite
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38 NPs (repeated NPs from the preamble, semantic substitutions, e.g. *the prince for the*
39
40 *king*). Using the WM score where language proficiency and age were partialled out
41
42 did not allow the model to converge, we therefore used the raw WM score. The
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44 optimal model shows that children were more informative in the presence of a visual
45
46 competitor ($z = 2.15, p = .03$), while the mention of a discourse competitor had no
47
48 significant effect ($z = -1.15, p = .25$). The interaction between WM and language
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50 proficiency was a significant predictor of informativity ($z = 9.59, p < .001$), while
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52 none of the other predictors made a significant contribution to the model.
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3 As we did earlier, we repeated this analysis including the mean monolingual
4 language proficiency as a threshold to investigate a potential language proficiency
5 disadvantage for bilingual children in the production of informative NPs. The effect
6 of visual competitor was significant ($z = 2.14, p = 0.03$), as was the effect of WM ($z =$
7 $4.88, p < .001$). Similarly to what we found in the first set of analyses, monolingual
8 children ($z = 3.56, p < 0.001$) and children with language proficiency above the
9 monolingual mean ($z = 9.51, p < 0.001$) produced significantly more informative NPs.
10
11 The significant interaction between language proficiency and language experience (z
12 $= -2.18, p = 0.03$) showed once again that there was no difference as a function of
13 language experience for children whose proficiency was above the monolingual
14 mean, but for those below the mean threshold monolinguals produced more
15 informative NPs.
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28 Our third and final set of analyses investigated the possible causes for not
29 encoding the target referent with a definite NP or a pronoun (which resulted in
30 exclusion from the first and the second analyses). This third analysis revealed
31 whether children were able to integrate the discourse information provided in the
32 preamble – where the target was introduced with or without a competitor – and the
33 target in their own scene description. The dependent variable was the definiteness of
34 the target expression used, a proxy measure for discourse integration. Only bare
35 nouns were excluded (44 items), on top of the items excluded from all analyses. The
36 excluded items amounted to 7.3% of the data in total. In this logistic regression
37 analysis, the coefficients indicate the likelihood of using a definite expression, thereby
38 integrating the target expression with the preceding discourse without discriminating
39 further between more informative full NPs and less informative pronouns. Very few
40 items displayed lack of discourse integration: 3% in monolinguals and 4% in
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3 bilinguals.

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5 The presence of a visual competitor adversely affected discourse integration (z
6 = -2.87, $p < .001$); children were more likely to use an indefinite expression, rather
7 than a definite NP, when a competitor was visually present. More exposure to the
8 home language also negatively affected the production of definite expressions in
9 bilingual children ($z = -2.96$, $p < .001$). Children with better cognitive control skills (z
10 = 3.14, $p < .001$) and boys ($z = 2.89$, $p < .01$) were more likely to produce a referential
11 expression that connected the target description to the previous discourse. Finally, the
12 significant interaction between the visual presence of a competitor and of its discourse
13 mention ($z = 2.26$, $p < .05$) indicates that children were more likely to introduce the
14 target referent anew in the presence of a visual competitor (and even more so when
15 the competitor had also been introduced in the discourse).
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28 We repeated this final analysis by including a language proficiency threshold
29 as we did previously and we confirmed a significant negative effect of the presence of
30 a visual competitor ($z = -2.94$, $p < .001$), a significant positive effect of cognitive
31 control ($z = 3.08$, $p < .001$), a significant effect of gender with boys outperforming
32 girls ($z = -2.88$, $p < .001$). There was a significant interaction between the presence of
33 a discourse competitor and cognitive control skills ($z = 2.34$, $p < .01$) with children
34 with better cognitive control skills producing more NPs in the presence of a
35 linguistically mentioned competitor. No other main effects or interactions were
36 significant.
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50 Discussion

51 The aim of this study was to investigate whether 5- to 7-year-old children,
52 with or without exposure to another language in addition to English, can use both
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3 discourse and visual information in a complex referential communication task.

4 Cognitive control skills, verbal WM, , language proficiency, language exposure and
5 use, and SES were investigated as predictors of the choice of discourse-appropriate
6 anaphoric expressions in the task.
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11 *The role of cognitive control and WM in referential choice*

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13 With the exception of analysis 2, cognitive control – as indexed by the Simon
14 task score – was a significant predictor of NP use. In analysis 1 and 3 – when a
15 language proficiency threshold is introduced as a predictor - better cognitive control
16 predicted sensitivity to the presence of a discourse competitor. In analysis 3, better
17 cognitive control also predicted discourse integration in the absence of the additional
18 language proficiency threshold.
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27 Within the context of the current experiment, the manipulation of the presence
28 and discourse mention of a competitor to the target referent unpredictably varied the
29 need to resolve a referential conflict. In the condition in which the target had no
30 linguistic or perceptual competition no conflict arose. However, in the remaining
31 three conditions the discourse and/or perceptual presence of a competitor created a
32 referential conflict. The resolution of this conflict required the children to both inhibit
33 the preferred choice of a pronoun for a recently mentioned target referent, and to use a
34 more informative referential expression (a NP) instead for the benefit of their
35 addressee. The unpredictability of an upcoming potential referential conflict
36 necessitated a level of monitoring that we hypothesised would correlate with their
37 cognitive control abilities as indexed by the performance on the Simon task.
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52 We never found an interaction between language experience and cognitive
53 control in the prediction of NP use suggesting that cognitive control abilities
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3 conferred an advantage to both groups of children independently of bilingualism,
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5 contrary to our initial hypothesis. This could be because the bilingual advantage for
6
7 cognitive control abilities in this group of children was modest (albeit significant, see
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9 also De Cat et al., 2017). In our predictions we also hypothesised that whatever
10
11 bilingual advantage there might be in cognitive control might be offset by bilingual
12
13 children's lower proficiency skills. We did find, at least in analysis 1 and 3, that the
14
15 degree of exposure and use of the home language negatively correlated with NP use
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17 before controlling for language proficiency. In an additional set of analyses we
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19 investigated whether keeping language proficiency constant for the monolingual and
20
21 the bilingual children might mitigate the proficiency disadvantage against the
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23 bilinguals. Using the mean performance of the monolingual children on the language
24
25 proficiency task we split the groups above and below the monolingual mean, and we
26
27 did repeatedly found that those bilingual children that had language proficiency skills
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29 above the monolingual mean were no different from their monolingual counterparts in
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31 the use of informative NPs. They were however no better, as might be expected on the
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33 assumption of a bilingual advantage in cognitive control. The reason for this lack of
34
35 bilingual advantage, once proficiency was controlled for, is likely to stem from the
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37 heterogeneity of our bilingual group. We deliberately had very broad selection criteria
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39 for the bilingual children in our recruitment schools so that we could include all of the
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41 children that were classified in the UK education system as having English as an
42
43 additional language (EAL learners). This resulted in children who differed vastly in
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45 the cumulative amount of input and output and in the range of languages spoken. As
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47 our understanding of the bilingual cognitive advantage is progressively refined we
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49 now know that a large number of variables, both at the level of the individual
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51 bilingual speakers and at the level of the tasks used (Mishra et al., 2012), can
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3 significantly affect the presence of said advantage. Among other things, language
4 distance, interactional situations – i.e. the degree to which bilinguals use their two
5 languages on a daily basis in conversational contexts (Green & Abutalebi, 2013) –
6 and immigrant status have all been shown to potentially play a role on the presence of
7 a bilingual cognitive advantage (Bialystok, 2017). In our sample we had a large range
8 of typologically different languages that are more or less closely related to English
9 (e.g. Swedish vs. Cantonese), and we did not collect information on children’s daily
10 pattern of interactional contexts, i.e. whether they were more likely to find themselves
11 in single-language situations, dual-language situations, or in contexts with a high
12 density of code-switching (see Green & Abutalebi, 2013, for the role of interactional
13 contexts on cognitive control). In the absence of this information we can therefore
14 only speculate as to the precise nature of the lack of a bilingual advantage.
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30 In relation to the experimental manipulations of the competitor, cognitive
31 abilities did not predict sensitivity to the presence of a visual competitor, presumably
32 because of young children’s very high sensitivity to visual cues (which was
33 unaffected by any participant-related factor), but they did interact with the discourse
34 mention of a competitor. This correlation between cognitive control and choice of NP
35 in the presence of a discourse competitor suggests that children with better conflict
36 monitoring abilities could inhibit the prepotent response to use a pronoun for a
37 referent that was highly salient to them and choose a more informative NP instead for
38 the benefit of their addressee.
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49 The significant effect of verbal WM in interaction with proficiency in analyses
50 1 and 2 indicates that in this linguistically complex referential communication task,
51 children with a higher WM capacity and better language proficiency were more
52 successful at using either a repeated, definite NP (analysis 1) or more informative
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3 expressions (analysis 2) for their listener. The lack of a significant effect for WM in
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5 analysis 3 shows that WM capacity did not correlate with discourse integration in
6
7 more general terms.
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9 Although both definite NPs and pronouns are anaphoric devices that refer
10
11 back to an antecedent in the common ground, the use of pronouns in the absence of
12
13 shared common ground suggests lack of perspective-taking. In that case, the pronoun
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15 is anaphorically appropriate for the speaker but not for the listener. Choosing a
16
17 referential expression purely from one's own privileged ground clearly does not
18
19 necessitate the complex evaluation of two different scenarios (the speaker's and the
20
21 listener's) and as such does not engage the same WM skills that are necessary when
22
23 multiple points of view are considered. If children are using pronouns inappropriately,
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25 because they are only considering the privileged ground, they are not making the
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27 "costly effort" of simultaneously considering their addressee's perspective, an attempt
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29 that would pose higher demands on their WM.
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33 Support for the role of verbal WM in the production of expressions in
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35 referential communication tasks with child speakers comes from two studies
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37 (Torregrossa, 2017; Wardlow and Heyman, 2016), that included an independent
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39 measure of verbal WM in a referential production task in school-age children.
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41 Wardlow and Heyman (2016) investigated how feedback affects children's use of
42
43 underinformative expressions (i.e. NPs lacking a disambiguating size adjective) and
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45 the role that WM plays in predicting their ability to actually use feedback to improve
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47 their perspective-taking and consequently use discourse-appropriate expressions for
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49 the benefit of a naïve instruction-follower. In their study WM was positively
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51 correlated with the use of a modifier (e.g. *big* in *the big triangle*) only in the feedback
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53 condition, although – despite the lack of a significant correlation in the no feedback
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55 condition, although – despite the lack of a significant correlation in the no feedback
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3 condition – there was no significant difference in the strength of the two correlation
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5 coefficients. This suggests that WM does facilitate children’s reliance on feedback to
6
7 increase their awareness of which referential expressions are needed in the absence of
8
9 shared common ground. At the same time this result does not exclude that WM might
10
11 be implicated in perspective-taking skills and the use of discourse appropriate
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13 referential expressions more widely. In contrast with the Wardlow and Heyman’s
14
15 (2016) study - where children were only required to provide a definite NP with or
16
17 without a modifying size adjective - and Nilsen and Graham (2009) - who did not find
18
19 a predictive relationship in their production study - our sentence-level referential
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21 communication tasks was considerably more complex both visually and linguistically.
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23 The linguistic and perceptual complexity of the present experiment is likely to have
24
25 been more taxing in terms of WM skills and hence the reason for our positive finding.
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27 From a computational point of view Hendriks (2016) has recently made the case for
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29 the crucial role of WM in tracking referents and in the choice of referring expressions.
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33 Language proficiency and WM interacted in analysis 1 and 2 to predict the use
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35 of a repeated definite NP (analysis 1), and of the informativeness of referring
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37 expressions (analysis 2), but in analysis 3 there was no contribution of either WM or
38
39 language proficiency. Children with a better mastery of definiteness distinctions in
40
41 English (as indexed by the DELV Articles sub-test) were more likely to use a
42
43 maximally informative referring expression. Higher proficiency was also likely to
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45 reflect children’s ability to parse the preamble sentence and, although we did not have
46
47 an independent measure of vocabulary, there is reason to expect that they were also
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49 more likely to have larger vocabularies that would include the referential labels used
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51 in the experiment (e.g. *fireman*, *astronaut*) or semantically related alternatives (e.g.
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53 *the prince* instead of *the king*). In analysis 3, proficiency did not appear to make a
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3 significant contribution, suggesting that it does not affect general discourse
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5 integration abilities in the age group studied here. More interestingly, when language
6
7 proficiency was controlled for across the bilingual and the monolingual groups, the
8
9 bilingual disadvantage disappeared. Once bilingual children functioned within the
10
11 monolingual range they were just as adept as their monolingual counterparts in this
12
13 complex referential communication task.
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16 In addressing the first two aims of our study we can conclude that cognitive
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18 control and WM positively correlate with the ability to use informative referential
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20 expressions in a task that taps into the use of anaphoric devices. In particular conflict
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22 monitoring interacted with the presence of a discourse competitor, the more
23
24 demanding of the two experimental manipulations. The effect of bilingualism on
25
26 referential abilities (as indexed in this task) is complex. On the one hand, it conferred
27
28 a disadvantage: children with reduced experience in English generally used less
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30 informative labels for the target referent, but they were no different from
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32 monolinguals once they were operating above the monolingual mean in terms of
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34 proficiency.
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38 ***Building a situation model: the impact of competitors (from discourse or visual***
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40 ***modalities)***

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42 At least two studies have previously used a referential communication task
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44 with children and measures of cognitive control skills and WM to explore the role of
45
46 individual differences in perspective-taking and referential choice (Nilsen & Graham,
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48 2009; Wardlow & Heyman, 2016). Neither of these studies however assessed the
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50 extent to which children can use anaphoric referential expressions in a sentential
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52 context; instead participants were simply required to use a colour or size adjective to
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54 disambiguate a referent for the benefit of a naïve listener. Our task was considerably
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3 more demanding. In addition to manipulating the linguistic mention and the visual
4 presence of a competitor, our task also required children to parse a sentence
5 containing an antecedent (e.g. *The astronaut*) that was embedded as the possessor in a
6 genitive 's-phrase (e.g. *The astronaut's bike has been found (by a boy). And now...*
7 *THE ASTRONAUT is cycling*) and hence was not the syntactic subject of the sentence.
8
9 The intended effect of not using a subject antecedent was to reduce the accessibility
10 of the referent in the discourse. The reduced linguistic saliency of the target referent
11 was also meant to increase the likelihood that the visual competitor – when present –
12 would become part of the situation model. This expectation was based on studies on
13 adults, who have been shown to take visual information into account (Fukumura et
14 al., 2010), but only when the visual competitor is sufficiently salient (Arnold &
15 Griffin, 2007). Finally, none of the previous studies addressed the role of bilingual
16 language experience in referential communication.
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33 A number of studies have investigated children's sensitivity to the discourse
34 status of the referent and its visual availability to the addressee (Campbell et al., 2000;
35 Demir et al., 2012; Graf, Theakston, Lieven & Tomasello, 2015; Matthews et al.,
36 2006; Serratrice, 2008, 2013). By crossing linguistic mention and visual presence of
37 a competitor in this study's design, we have been able to assess the relative and joint
38 contribution of both factors to the speaker's discourse model.
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46 Across our three analyses the repeated finding is that children were strongly
47 influenced by the presence of a visual competitor, but much less by that of a discourse
48 competitor. When looking at a scene with only one visually available referent,
49 children were less likely to use a full NP than when two referents were visually
50 present. In contrast, whether a discourse competitor had been mentioned in the
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3 preamble or not significantly affected NP use only in children with higher cognitive
4 control skills. The lack of a significant interaction between the two experimental
5 conditions in the first analysis shows that the mention of a discourse competitor did
6 not increase the likelihood of NP use significantly above and beyond what was driven
7 by the visual presence of a referent alone. This result differs from the findings for
8 adult speakers by Fukumura et al. (2010) where both the visual presence and
9 discourse mention of a competitor significantly affected the use of NPs, and where a
10 trend towards an interaction suggested that the effect of linguistic mention and visual
11 context were not independent. Children at the ages tested here appear to be much
12 more sensitive to the visual modality than the discourse modality (De Cat, 2015).
13 Taking the latter into account appears to have demanded a greater cognitive effort, as
14 indicated by the significant interaction with the Simon score.
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29 An additional factor explaining the challenge of discourse mention in these
30 children is the complexity of the preamble sentence, as discourse competitors were
31 introduced in the *by*-phrase of a passive construction. The minimal assumption
32 underlying the creation of a discourse model is that the linguistic input must be parsed
33 and meaningfully understood, i.e. syntactic and thematic roles must be assigned as
34 relevant. An agent appearing in a *by*-phrase is not as salient as an agent appearing in
35 subject position (usually corresponding to the topic in English), or a patient appearing
36 in object position (usually in focus) in a canonical active sentence. It is therefore
37 possible that the syntactic position in which the competitor appeared decreased its
38 saliency so much that it became unlikely to interfere in any meaningful way with the
39 saliency of the target referent. We know that English-speaking children have some
40 difficulties with full passives into the early school years; truncated adjectival passives
41 are comprehended and produced earlier than full actional passives including an agent
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3 in the *by*-phrase (Maratsos, Fox, Becker & Chalkley, 1985) and syntactic priming of
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5 full passives does not have long-lasting effects a week after training in 5-year-olds
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7 (Kidd, 2012). It may be that the NP in the *by*-phrase was not fully parsed in our task,
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9 or only superficially so in some form of shallow processing, further reducing the
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11 likelihood that it could be incorporated into the discourse model and lead to
12
13 referential competition with the target. However, we did not find an interaction
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15 between proficiency and discourse competitor – which would be expected if our
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17 parsing hypothesis was along the right lines.
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20 The finding that only the children who had better cognitive control skills
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22 produced more NPs when a competitor was mentioned speaks to the role of conflict
23
24 monitoring skills in referential production. It also adds to the results of corpus studies,
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26 which have shown that even pre-school children use a more informative referential
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28 expression and/or omit fewer arguments when a referent has more than one potential
29
30 antecedent (Allen, 2000; Clancy, 1992; Serratrice, 2005). The artificiality of our
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32 experimental task and the associated cognitive demands made it harder for children to
33
34 be able to demonstrate these skills.
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37 In contrast, and similarly to what has been found for adults, the salient visual
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39 presence of a competitor, whether it was linguistically mentioned or not, did affect
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41 children's use of NPs. This is evidence that, even in the absence of linguistic mention,
42
43 a referent can become part of the discourse model for children as it does for adults.
44
45 However, the lack of an interaction between visual and discourse information, in the
46
47 children's case, is likely to be due to the primacy for visual information (De Cat,
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49 2015).
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52 **Conclusion**

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54 The findings of this study point to a significant role of cognitive control,
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3 verbal WM capacity and language proficiency in accounting for individual
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5 differences in the choice of anaphoric referential expressions in both bilingual and
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7 monolingual children. They also shed some light on the complex interaction between
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9 cognitive control, language experience, and language proficiency. Given the
10
11 heterogeneity of our sample we are at present not in a position to say what other
12
13 factors that are integral to the bilingual language experience can further modulate this
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15 interaction. We deliberately chose a heterogeneous but representative sample of
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17 bilingual children in the kind of multilingual classroom that is nowadays common in
18
19 many English-speaking countries. The downside of this approach is that we could not
20
21 isolate and control for specific variables such as language distance, immigration
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23 status, different types of interactional contexts. Future research should address these
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25 factors more systematically to further refine our understanding of how the language
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27 experience shapes both the cognitive and linguistic dimensions of bilingual speakers.
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For Peer Review

Table 1. *Bilingual and monolingual participants by gender, age, SES, and cumulative language exposure and use (bilinguals only)*

	Gender	Age in months	SES	BPI index
Bilinguals (n = 87)	F (n = 44)	70.60 (5.72)	-8.18 (3.81)	.39 (.22)
Monolinguals (n = 87)	F (n = 52)	71.94 (7.00)	-7.03 (3.40)	-

Table 2. *Language proficiency, WM and cognitive control scores*

Task	Group	Range	Mean (SD)
Language Proficiency	Bilingual	0.17 – 1.00	0.63 (0.21)

	Monolingual	0.30 – 1.00	0.77 (0.16)
WM	Bilingual	0.00 – 4.00	2.55 (0.74)
	Monolingual	2.00 – 4.00	2.67 (0.54)
Cognitive control	Bilingual	-.072 – 0.78	-0.08 (0.32)
	Monolingual	-.055 – 0.72	0.08 (0.38)

For Peer Review

Appendix

The by phrase in parentheses was included as part of the experimental sentences when the item was presented in the competitor mentioned condition.

List of experimental and filler items

Practice sentences

This is a sweet dog

Woman petting dog

The lady's cup has been washed

Lady picking up the cup

Experimental sentences

1. The uncle's hat has been found (by a postman)

And now... [uncle wearing hat]

2. The ghost's trailer has been built

And now... [ghost standing in trailer]

3. The child's rucksack has been packed (by a teacher)

And now... [child wearing rucksack]

4. The girl's cake has been baked (by a teacher)

And now... [girl eating cake]

5. The fireman's bed has been made (by a pirate)

And now... [fireman sleeping]

6. The astronaut's bike has been found (by a boy)

And now... [astronaut cycling]

7. The boy's lamp has been lit (by a king)

And now... [boy filling jar]

8. The granddad's sword has been cleaned

And now... [granddad swinging sword]

9. The cowboy's ball has been kicked (by a footballer)

And now... [cowboy collecting ball]

10. The musician's drums have been installed (by a soldier)

And now... [musician playing drums]

11. The queen's basket has been filled (by a girl)

And now... [queen emptying basket]

12. The woman's table has been cleaned (by a vet)

And now... [woman lying down on table]

13. The gardener's lawnmower has been repaired (by a doctor)

And now... [gardener pushing lawnmower]

14. The cowboy's gun has been picked up (by a boy)

And now... [cowboy holding gun]

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2
3 15. The dentist's chair has been fixed And now... [dentist sits in chair]
4
5 16. The teacher's slippers have been washed (by a
6
7 king) And now... [teacher wearing slippers]
8
9 17. The mother's ladder has been painted And now... [mother climbing ladder]
10
11 18. The gardener's plant has been watered (by a
12
13 ghost) And now... [gardener trimming plant]
14
15 19. The fireman's bucket has been filled (by a
16
17 musician) And now... [fireman carrying bucket]
18
19 20. The girl's lawn has been cut And now... [girl watering lawn]
20
21

22 **Filler sentences**

- 23
24 1. There's a big circle and a small circle And now ... [small circle
25
26 partially overlapping the big circle]
27
28 2. There's a green square and an orange square And now... [the green square
29
30 has doubled in size]
31
32 3. There's a grey triangle and a red triangle And now... [a duck has
33
34 appeared between the two triangles]
35
36 4. There's a red triangle and a blue triangle And now... [the blue triangle has
37
38 moved over to the red triangle]
39
40 5. There's a red circle and a red square And now... [a cow has appeared
41
42 on the square]
43
44 6. There's an orange circle and a red circle And now... [a pig has appeared
45
46 below the orange circle]
47
48 7. There's a pink square and an orange square And now... [the orange square
49
50 has shrunk to half its size]
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3 8. There's a pink square and a green square And now... [a sheep has
4
5 appeared above the pink square]
6
7 9. There's a grey circle and a blue circle And now... [a donkey is lying on
8
9 the blue circle]
10
11 10. There's a red circle and a red square And now... [the red circle has
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13 been replaced by a an orange circle]
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For Peer Review

Highlights

- Bilingual and monolingual children's use of full Noun Phrases (NPs) in a complex referential task was predicted by the visual presence of a competitor more than by its linguistic mention.
- Verbal working memory and proficiency predicted NP use.
- Cognitive control skills predicted both the ability to use expressions signaling discourse integration and sensitivity to the presence of a discourse competitor, but not of a visual competitor.
- Bilingual children were as informative as monolingual children when language proficiency was controlled for

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First picture in the no visual competitor conditions

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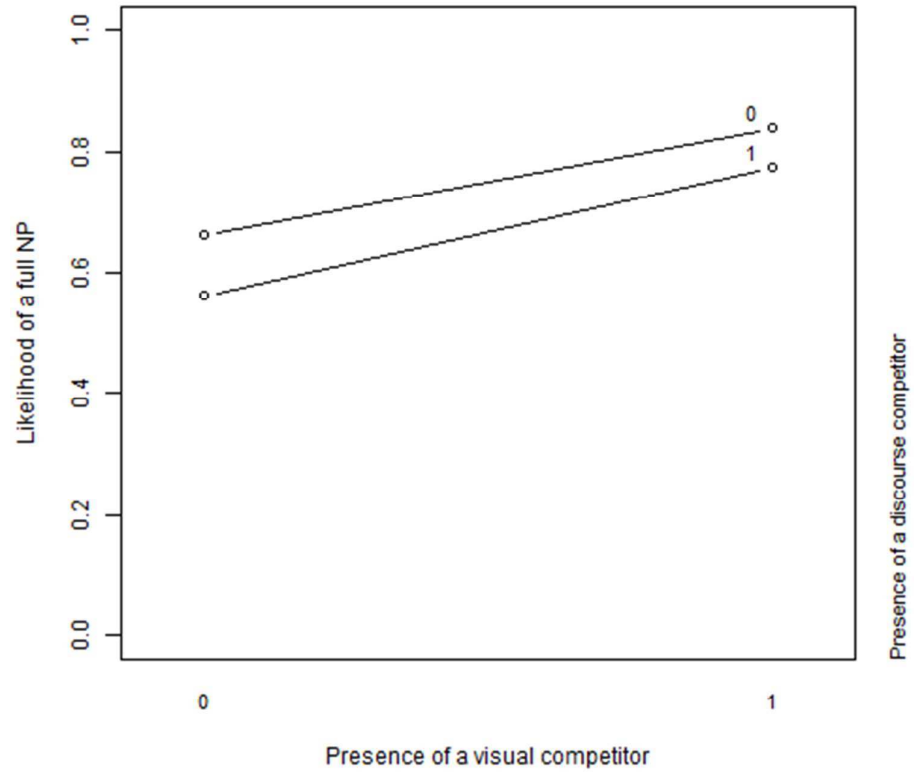


First picture in the visual competitor conditions

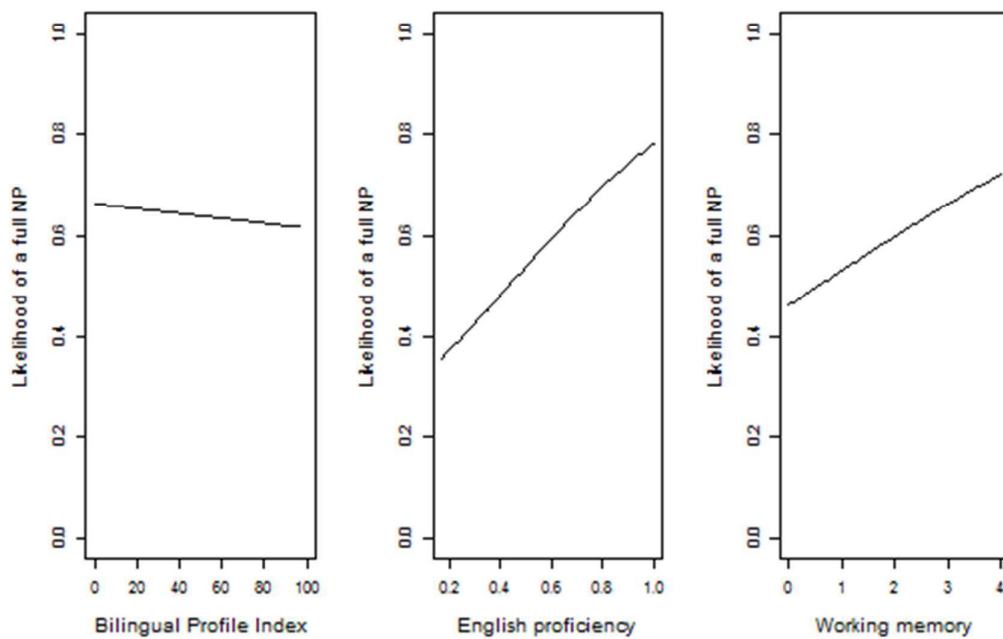
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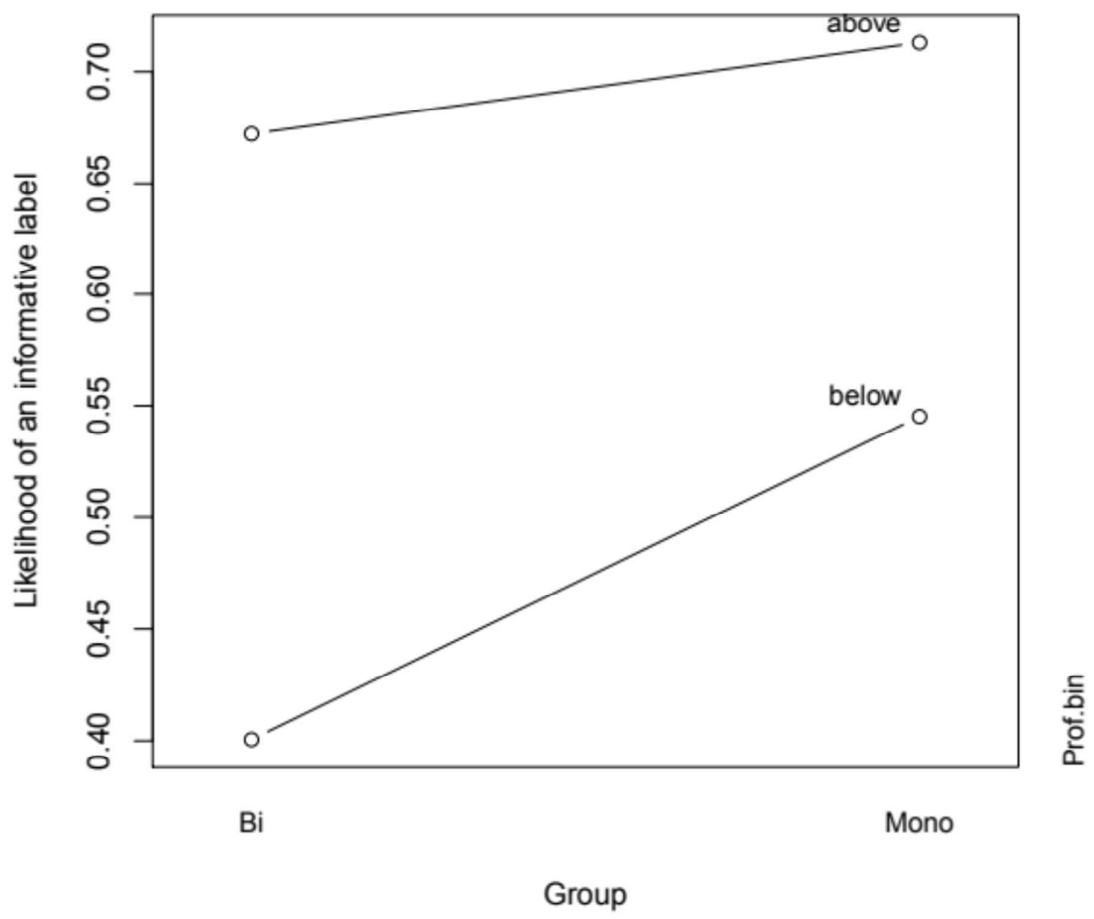
Review



Peer Review

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