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Tip-of-the-tongue in a second language: The effects of brief first-language exposure and long-term use

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ABSTRACT

Bilinguals have more tip-of-the-tongue (TOT) incidents than monolinguals. Whereas previous research has focused on differences in the long term language experience between these groups, the present study examined the hypothesis that both long-term and transient context factors modulate TOT rates. Russian–Hebrew bilinguals who acquired Hebrew either early (<5 years) or late (>11 years) were compared to native Hebrew speakers on a picture naming task in Hebrew, before and after viewing a short movie in Russian. Both the short-term context (before–after the movie) and long-term language experience modulated TOT rates: Late bilinguals exhibited significantly higher TOT rates than early bilinguals who did not significantly differ from native Hebrew speakers. Critically, following the Russian movie, bilinguals in both groups differed from the native speakers of the target language. Thus, exposure to the non-target language exerted a global, non-item-specific, cross-language interference effect. The findings highlight the dynamic nature of the bilingual system in which both short and long-term language experience operate to influence bilingual performance.

1. Introduction

One of the most frustrating difficulties bilinguals experience during production is the tip-of-the-tongue (TOT) state (Brown & McNeill, 1966), which is a temporary difficulty in retrieving words in one of the languages they speak. Interestingly, TOT incidents are not confined to bilinguals, but bilinguals consistently exhibit higher TOT rates than monolinguals (e.g., Gollan & Silverberg, 2001). The research that investigated bilingual TOT has initially focused on general long-term differences in language experience between bilingual and monolingual speakers (e.g., Gollan & Acenas, 2004). However, many bilinguals shift flexibly from one language to another, and such brief language exposure may additionally affect bilinguals' TOT rates. In the current study, we examine how TOT rates are modulated by both long-term and very recent short-term language exposure. Further, we test to what extent global, non-item-specific effects emerge from such brief language exposure.

Differences in language experience have been shown to affect TOT rates. For example, Gollan and Silverberg (2001) showed increased TOT rates in Hebrew–English bilinguals compared to age matched English monolinguals. Similar effects were shown with Spanish–English and Tagalog–English bilinguals (Gollan & Acenas, 2004), and with American Sign Language (ASL)-English bimodal bilinguals (Pyers, Gollan, & Emmorey, 2009). Notably, bilinguals do not differ from monolinguals in TOT rates for cognates (Gollan & Acenas, 2004) and proper names (Gollan, Bonanni, & Montoya, 2005) suggesting that this group difference is rooted in the linguistic system, and not in

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domain general faculties such as memory or attention (e.g., Bialystok, 2009).

Two general accounts have been proposed to explain such bilingual difficulties in production. The *Frequency-Lag* (or *Weaker-Links*) hypothesis (Gollan & Acenas, 2004; Gollan, Slattery, Goldenberg, Van Assche, Duyck, & Rayner, 2011) postulates that bilinguals divide their time between two languages so their frequency of use in each language is reduced. Consequently the connections in the bilingual lexical system are weaker, which in turn leads to increased difficulty in retrieving words. This account highlights accumulating frequency of use as the underlying factor that explains the bilinguals' higher TOT rates compared to monolinguals. Notably, this account can explain differences between bilinguals and monolinguals that are not due to simultaneous activation of both languages, such as the higher TOT rates of bilinguals for words they know in just one of their languages (Gollan & Acenas, 2004).

By contrast, the *Dual-Language activation* account focuses on processes that take place at the time of production and comprehension. This account emphasizes processes that arise from the co-activation of both of the bilingual's languages while performance in one language is expected (Hermans, Bongaerts, De Bot, & Schreuder, 1998). This account suggests that production in the target language is hindered due to competition from non-target language elements. Moreover, prior exposure to the non-target language reduces target language accessibility either because it increases the activation of non-target language elements making them more effective competitors, or because such prior exposure requires that the target language is inhibited (Green, 1998) and subsequently necessitates recovery from inhibition (for elaborate discussions see Kroll, Bobb, & Wodniecka, 2006; Van Assche, Duyck, & Gollan, 2013). The effects of such dual-language activation were recently demonstrated in a TOT paradigm involving translation priming (Gollan, Ferreira, Cera, & Flett, 2014). Specifically, Spanish–English bilinguals performed a picture naming task in English, after being primed with the Spanish translation of the picture name. Translation primes significantly increased TOT rates, suggesting that even very limited exposure to words in one language can affect production in the other. Moreover, translation-equivalent primes reduced retrieval rates ("GOT" responses) compared with non-related primes, suggesting that the dual-language activation increased TOT rates because co-activation interfered with retrieval rather than facilitated speakers' ability to get out of the pre-TOT failure.

Gollan et al.'s (2014) priming study showed item-based effects in which immediate exposure to particular items in the non-target language affected retrieval of the translations of these items in the target language, in a trial-by-trial design. Similar effects were shown in a picture naming study where exposure to specific items in the non-target language was manipulated in blocks rather than a trial-by-trial design (Misra, Guo, Bobb, & Kroll, 2012). Both reaction times and event-related potentials (ERPs) measures showed dual-language activation effects associated with naming pictures in the other language on a previous block of trials. Whereas the *dual-language activation* account explains these effects as the result of cross-language interference due to simultaneous activation of the specific items in both languages, the *Frequency-Lag* account may explain this effect in terms of recency of use, where recent use disproportionally changes the strengths of the connections of particular items. Thus, although they offer different explanations, both accounts can explain such short-term item-based effects. The two accounts may not be mutually exclusive but rather it is plausible that both reduced frequency of use and interference due to dual-language activation operate simultaneously to increase TOT rates in bilinguals relative to monolinguals (see also Gollan et al., 2014).

Importantly, short-term effects may not be limited to specific items. Instead, exposure to the non-target language may operate at a more general level, affecting global language activation (see also Guo, Liu, Misra, & Kroll, 2011; Van Assche et al., 2013). For example, Van Assche et al. (2013) asked bilingual speakers to produce words starting with a specific phoneme. Retrieving words that start with specific phonemes in one language reduced fluency of production in the other language, even when production did not involve repeated phonemes. Although it was present only in one group of bilinguals (Chinese–English but not Dutch–English bilinguals), this finding suggests that production in one language can exert global, rather than item-based, cross-language effects on production in the other language. Global effects of brief exposure to the non-target language were also demonstrated in comprehension. Specifically, Elston-Güttler, Gunter, and Kotz (2005) found that target word recognition was influenced by prior comprehension of a movie in the non-target language. However, in a study comparing bilingual and monolingual performance on reading and picture naming tasks, Gollan et al. (2011) observed differences between these language modalities, suggesting that in production lexical access is primarily semantically driven whereas in comprehension it is predominantly frequency-driven. In view of these differences it is not clear whether brief exposure involving only comprehension (as in Elston-Güttler et al., 2005) will generalize to affect subsequent production. In the current study we therefore investigate the influence of comprehension on production and examine whether global cross-language effects can arise from recent brief *comprehension* of the non-target language (i.e., short movie) to influence *production* in the target language in a TOT paradigm.

Global cross-language effects in bilingual *production* require further specification of the dual-language activation account. In particular, item-based effects were interpreted as arising from co-activation and competition between corresponding lexical items in the two languages suggesting that the language of production is selected at the stage of lexical retrieval. In contrast global effects may suggest different loci of language selection. In a review of bilingual production studies, Kroll et al. (2006) suggest that the locus of selection is dynamically determined by factors associated with both long-term language experience and the immediate production context. Hence, they propose a dynamic system of lexical selection where both languages are active and potentially compete with

each other during the different stages of production up to the execution of phonology (Kroll et al., 2006). Within the framework of such a dynamic selection system, the *dual-language activation* account can explain global effects even after brief exposure to the non-target language. For example, if sub-lexical elements such as phonological units compete, they may interfere with each other to yield a global effect that is not associated with exposure to specific items. Moreover, if the target language is globally inhibited during production of the non-target language, subsequent production will be hindered. Conversely, the *Frequency-Lag* account does not seem to offer a mechanism to account for global non-item-based cross-language effects because frequency of use is assumed to modulate the specific lexical connections used.

Global cross-language effects have been shown in studies that examined the influence of *prolonged* exposure to the non-target language. For instance, Linck, Kroll, and Sunderman (2009) showed that L2 learners immersed in an L2-speaking environment experienced reduced access to words in their L1 compared to classroom L2 learners (see also Baus, Costa, & Carreiras, 2013). This reduced access disappeared upon return to their home country, highlighting the transient nature of the effect (see also Dussias & Sagarra, 2007, for immersion effects on syntactic performance). Critically, in such studies exposure to the non-target language was prolonged and included both comprehension and production. In the current study we test the global influence of a short exposure that includes only comprehension.

Taken together the findings reviewed above suggest that bilingual speakers experience difficulties in L2 production as a result of factors that operate on both long and short time-scales. On the long-time scale, prolonged differences in language experience were previously manipulated as differences between bilinguals and monolinguals (e.g., Gollan & Acenas, 2004). Here, in contrast, we compare TOT rates of early and late bilinguals and use these group differences to examine the effects of long-term language experience. On the short time-scale mainly item-based effects have been examined to date (e.g., Gollan et al., 2014), and when *global* effects were tested they were examined within the same language modality (production on production effects, Van Assche et al., 2013; comprehension on comprehension effects, Elston-Güttler et al., 2005). Here, we extend this line of research to examine how short-term exposure in the form of comprehension influences production performance. We compare TOT rates in participants' L2 before and after exposure to a short movie in their L1 (Russian). Critically, our short-term recent exposure is not item-based, because we examine TOT rates on items that were not included in the brief exposure (nor were their translations).

The *Frequency-Lag* hypothesis and the *dual-language activation* are sometimes considered as competing accounts. Nevertheless, in the context of the current study, these theoretical accounts seem to offer complementary predictions highlighting different aspects of the bilingual language system. The *Frequency-Lag* hypothesis predicts higher TOT rates for bilinguals compared to monolinguals. In the current study we extend the scope of this prediction to predict higher TOT rates in L2 for late bilinguals compared to early bilinguals, because the latter have been using their L2 for a longer period and consequently differ in their preference to use Hebrew over Russian and in their accumulated frequency of Hebrew use. However, the *Frequency-Lag* account does not seem to offer a mechanism that would affect the accessibility of items that were not specifically presented in the non-target language. The *dual-language activation* account within the framework of a dynamic language selection system (Kroll et al., 2006) provides the complementary prediction. Assuming that both languages are co-activated, exposure to the non-target language would increase its activation and/or decrease the activation of the target language. If this change of activation occurs at a whole-language level as suggested by Van Assche et al. (2013), it may affect different stages of production including lexical access and phonological planning (Kroll et al., 2006). Consequently, brief exposure to the non-target language is predicted to lead to a non-item-based increase in TOT rates compared to their baseline just prior to the exposure.

In sum, the present study is designed to test the hypothesis that passive exposure to L1 (via comprehension rather than production) can exert a global rather than item-specific negative effect on production in L2. If such global effects emerge, production of a given word will be hindered following exposure to the non-target language even when that exposure did not include the particular item to be produced, its translation or related words. Moreover, we test the hypothesis that both factors that operate on a short time-scale and factors that operate on a long time-scale contribute to the occurrence of TOT. On the short time-scale, the effect of recent brief exposure to the non-target language is examined by comparing TOT rates in Hebrew (L2) before and after viewing a short Russian (L1) movie. On the long time-scale, the effect of life-long language experience is examined by comparing early and late Russian–Hebrew bilinguals. In addition, we compare these groups to a group of native Hebrew speakers that serve as a control group. These participants are not pure monolinguals because they have some proficiency in English, but in this sense they do not differ from the participants in the experimental groups who possess similar English proficiency. Thus, although our control participants were not monolinguals (in contrast to some previous studies, e.g., Gollan & Acenas, 2004) the critical difference remains in that the experimental groups are highly proficient in an additional language (Russian–Hebrew–English vs. Hebrew–English), and this language will be manipulated during the brief exposure phase. Hence, this participant selection should not undermine our ability to test hypotheses concerning differences between early and late bilingual speakers and their sensitivity to recent brief exposure to the non-target language.

2. Method

2.1. Participants

Seventy-two participants (19 males), took part in the study. Of these, 24 native Hebrew speakers with no

Table 1
Means (and standard deviations) of language experience characteristics.

Measure	Late Bilinguals	Early Bilinguals	Native Hebrew Speakers
Age (years)	26.88 (3.08)$_a$	24.46 (1.44)$_b$	24.25 (1.65)$_b$
Hebrew AOA (years)	12.92 (1.32)$_a$	3.19 (.70)$_b$	N/A
Preferred use of Hebrew vs. Russian			
Speaking	1.89 (.50)$_a$	3.28 (.86)$_b$	N/A
Media	3.25 (.88)$_a$	4.56 (.56)$_b$	N/A
Inner Speech	2.87 (1.05)$_a$	4.54 (.81)$_b$	N/A
All (average)	2.67 (.73)$_a$	4.13 (.56)$_b$	N/A

Note. Means in the same row that do not share sub-scripts differ at $p < .05$ level in a *t*-test with the Bonferroni correction for multiple comparisons where applicable. Preferred use was estimated using a self-rating questionnaire of 20 items inquiring about the preferred language in different contexts including speaking, media, and inner speech. Bilinguals rated their preference on a 1–5 scale indicating a preference to use only Russian (1), more Russian than Hebrew (2), equal use of Russian and Hebrew (3), more Hebrew than Russian (4), or only Hebrew (5).

knowledge of Russian served as a control group. Forty-eight native Russian speakers who had immigrated to Israel and acquired Hebrew as L2 were recruited from two groups: early bilinguals who acquired Hebrew before age 5 and late bilinguals who acquired Hebrew after age 11. Participants in both experimental groups indicated still speaking Russian with their families and some indicated speaking it with friends as well (see also preference ratings in Table 1). Participants in both groups have finished high school in a Hebrew speaking school, and at the time of testing were undergraduate students at a Hebrew speaking academic institution where good proficiency in Hebrew is an entry requirement, and all interactions are conducted in Hebrew (including classroom teaching, paper submission and exams). The two Russian–Hebrew groups differ in their preference to use Russian over Hebrew, such that early bilinguals prefer to use more Hebrew, and hence the two groups differ not only in age of acquisition of L2 but also in frequency of use of both languages. All participants were moderately proficient in English as a foreign language, as English is taught in schools starting from elementary school and a medium level English proficiency is an entry requirement for undergraduate studies. Thus, the critical difference between participants in the control group and the two experimental groups is that the experimental groups are proficient in both the target language (their L2) and the brief exposure language (their L1), whereas the control group are native speakers of the target language but have no knowledge of the brief exposure language. Details of participants' language experience are presented in Table 1.

2.2. Materials

Stimuli in the picture naming task included 182 line drawings from Snodgrass and Vanderwart (1980) that depict referents with low-to-medium frequency. Their Hebrew frequency counts ranged from 1 to 920 per million, with a mean of 23.6 based on the Word-Frequency database for written Hebrew (Frost & Plaut, 2005). Stimuli were divided into 2 lists of 91 pictures each, matched on item frequency ($t < 1$) such that one list was presented prior to the movie and the other was presented following the movie, with list order counterbalanced across participants. The order of picture presentation within each list was initially randomized and then kept constant for all participants. No cognates were included in the stimuli. Brief L1 exposure included a 10-min clip from the Russian movie "Love in the big city" ("Любовь в большом городе"), presented with no subtitles. The clip was selected such that none of the words included in the naming task was mentioned in its Russian translation in the movie.

2.3. Procedure

Although bilinguals were aware they were recruited due to their knowledge of Russian and Hebrew, all instructions and communication were conducted in Hebrew. Participants were first told that the "Tip of the Tongue phenomenon is a situation in which you are trying to recall a particular word that you are sure you know but cannot recall at the moment" (Gollan & Acenas, 2004). Pictures were then presented one by one on a computer screen and participants were asked to name them in Hebrew. They were instructed to respond in one of three ways (a) by naming the object, (b) by saying they do not know the name of the object, or (c) by saying that they could not recall now, but might be able to recognize the word if they heard it. When the picture was correctly named it was coded as "Got". If the participant said they did not know the name, it was coded as "Dontknow". If they anticipated they might be able to recognize the word, the experimenter returned to this item after presenting all 91 pictures, and asked the participant again to name the picture. The item was coded as a "TOT" if participants either recalled it correctly, or recognized the word when the experimenter named it. If they failed again at this stage, it was coded as "Dontknow". Participants were instructed to respond immediately and the experimenter prompted a response if they delayed.

Following this task, all participants viewed the short Russian movie. Immediately after the movie the picture naming task was repeated with the second set of 91 pictures. Finally, participants completed a short language use questionnaire to measure their preference to use Russian over Hebrew.

3. Results

The number of responses recorded in each of the scoring categories (i.e., "GOT", "TOT", "DontKnow") for each group is presented in Table 2. Analyses were performed

Table 2
Mean percent (and standard deviation) of responses in each scoring category as a function of context and group.

Context	Response type	Participant group		
		Late bilinguals	Early bilinguals	Native Hebrew speakers
Pre-movie	Got	90.75 (4.99)$_a$	96.84 (2.03)$_b$	98.12 (1.67)$_b$
	TOT	7.19 (3.32)$_a$	2.75 (2.05)$_b$	1.74 (1.68)$_b$
	Dontknow	2.06 (2.70)$_a$	.41 (.63)$_b$	.14 (.49)$_b$
	PercentTOT	7.38 (3.53)$_a$	2.76 (2.05)$_b$	1.74 (1.68)$_b$
Post-movie	Got	84.71 (7.77)$_a$	92.67 (4.21)$_b$	96.34 (1.88)$_{b*}$
	TOT	11.45 (5.19)$_a$	6.23 (4.10)$_b$	3.02 (2.06)$_c$
	Dontknow	3.85 (4.95)$_a$	1.10 (1.69)$_b$	.64 (.85)$_b$
	PercentTOT	12.00 (5.75)$_a$	6.29 (4.15)$_b$	3.04 (2.06)$_c$
Difference	Percent TOT	4.62 (4.09)$_a$	3.53 (3.25)$_{a,b}$	1.29 (1.74)$_{b*}$

Note. Means in the same row that do not share sub-scripts differ at $p < .05$ level in a *t*-test with the Bonferroni correction for multiple comparisons; $*$ indicates a marginally significant effect.

on the percentage of TOT, computed as the number of TOT divided by the sum of GOT and TOT. This measure controls for the number of opportunities to experience TOT by removing unknown items for each participant (Gollan & Brown, 2006).[1]

A mixed repeated measures Analysis of Variance examined the effects of context (pre and post-movie, within-participant factor), language group (control, early bilinguals, late bilinguals, between-participant factor) and the interaction between them. The results reveal a main effect of context, $F(1,69) = 70.54$, $MSE = 5.05$, $p < .001$, $\eta_p^2 = .51$, and a main effect of group, $F(2,69) = 34.48$, $MSE = 19.61$, $p < .001$, $\eta_p^2 = .50$, qualified by a significant interaction, $F(1,69) = 6.81$, $MSE = 5.05$, $p = .002$, $\eta_p^2 = .17$ (see Fig. 1).

Follow-up tests reveal that prior to the Russian movie there was a significant group effect, $F(1,71) = 33.40$, $MSE = 6.50$, $p < .001$, $\eta_p^2 = .49$. Pair-wise comparisons with Bonferroni corrections reveal that late bilinguals produced significantly more TOTs ($M = 7.38$) than early bilinguals ($M = 2.76$), and controls ($M = 1.74$), with no reliable difference between early bilinguals and controls ($p = .516$). In contrast, after watching the Russian movie, a significant group effect, $F(1,71) = 27.17$, $MSE = 18.17$, $p < .001$, $\eta_p^2 = .44$, was accompanied by reliable differences among all three groups (all $p < .04$), with late bilinguals producing more TOTs ($M = 12.00$) than early bilinguals (M = 6.29), who in turn produced more TOTs than controls ($M = 3.04$). Similar group differences were observed when age was used as a covariate in the analysis, refuting the interpretation that age differences among the groups (see Table 1) can explain the observed pattern of results.

We next examined the effect of context for each group separately. The context effect was reliable in all three groups, $F(1,23) = 30.52$, $MSE = 8.37$, $p < .001$, $\eta_p^2 = .57$ for late bilinguals; $F(1,23) = 28.34$, $MSE = 5.28$, $p < .001$, $\eta_p^2 = .55$ for early bilinguals; $F(1,23) = 13.35$, $MSE = 1.51$, $p = .001$, $\eta_p^2 = .37$ for native Hebrew speakers. However,

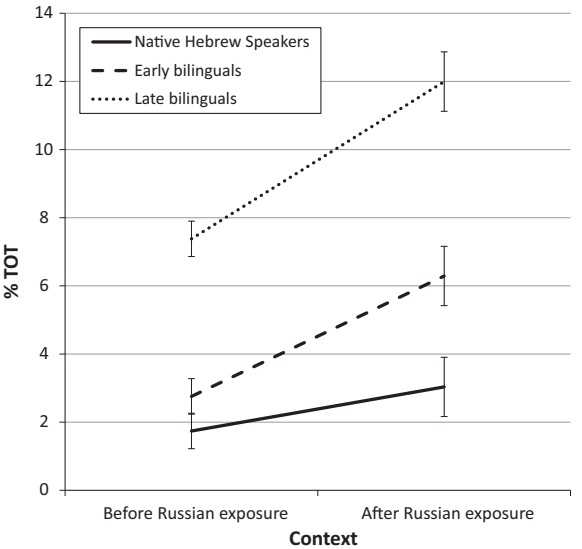

Fig. 1. Percent of TOT occurrences before and after watching a movie in Russian as a function of language experience group.

the interaction between context and group was significant even when separately comparing the control group to late bilinguals, $F(1,47) = 13.08$, $MSE = 4.89$, $p = .001$, $\eta_p^2 = .22$, or to early bilinguals, $F(1,47) = 30.51$, $MSE = 3.23$, $p = .004$, $\eta_p^2 = .16$. This finding indicates reduced context effects for the control group. Interestingly, the effect of context did not differ between the two bilingual groups ($F < 1$).

To further examine the unpredicted effect of context (i.e., the Russian movie) for the control group, we conducted a follow-up experiment with a different group of 24 native Hebrew speakers of similar age and language skills. This follow-up experiment was identical to the main experiment in all details except that the movie was now a 10 min clip of a comparable movie in *Hebrew*. The results show no effect of context for these participants, $F < 1$, such that TOT rates prior to the movie ($M = 1.09$) were comparable to those following the movie ($M = .85$). A direct comparison of participants from the follow-up experiment with the control group who saw the Russian movie yielded a significant context effect, $F(1,46) = 5.75$, $MSE = 1.16$,

[1] The same pattern of results was found when raw TOT counts or proportion of GOT responses were used. Specifically, a significant group by context interaction effect was found in raw TOT, $F(2,69) = 6.13$, MSE = 4.67, $p = .004$, $\eta_p^2 = .15$, and in proportion of GOT, $F(2,69) = 9.38$, MSE = 5.82, $p < .001$, $\eta_p^2 = .21$.

$p = .021$, $\eta_p^2 = .111$, and critically a significant context by movie type interaction, $F(1,46) = 12.138$, $MSE = 1.16$, $p = .001$, $\eta_p^2 = .209$. This pattern indicates that the effect of context was significantly detrimental for those who saw a Russian movie, as mentioned above, but was not significant for those who saw a Hebrew movie. Moreover, the two groups did not differ from each other in TOT rates before the movie, $F(1,47) = 2.284$, $MSE = 2.252$, $p = .138$, $\eta_p^2 = .047$, but were significantly different from each other following the movie, $F(1,47) = 19.644$, $MSE = 2.923$, $p < .001$, $\eta_p^2 = .299$, such that native Hebrew speakers exhibited more TOTs when naming pictures in Hebrew following the Russian movie ($M = 3.035$) than following the Hebrew movie ($M = .847$).

4. Discussion

The results show that TOT rates are modulated by both accumulated long-term language experience of early vs. late bilinguals and brief language experience in the context immediately preceding the use of the target language. In particular, late bilinguals exhibited significantly more TOT rates in L2 than early bilinguals, and both groups exhibited increased TOT rates following brief L1 exposure. In addition, native Hebrew speakers showed an unexpected increase in TOT rates following the Russian movie, but a follow-up experiment indicated no such increases following a movie in Hebrew. In what follows we discuss first the implications of the long-term experience effect, then the implications of the short-term experience effect, and finally propose an integrated theoretical explanation of the findings.

4.1. Long-term experience and TOT

The difference observed in the current study between late bilinguals and native Hebrew speakers is consistent with previous findings (e.g., Gollan & Silverberg, 2001), and can be readily explained by the *Frequency-Lag hypothesis* (Gollan & Acenas, 2004) as the result of weaker connections in the bilingual lexicon due to less frequent use of L2. Moreover, our findings show higher TOT incidence for late compared to early bilinguals and thus extend the scope of the *Frequency-Lag hypothesis*. These findings clearly demonstrate that accumulated frequency of use modulates TOT rates because the two bilingual populations differ in the number of years they have been using their L2 Hebrew, in their preference to use L2 over L1, and consequently in their accumulated frequency of Hebrew use. This finding strongly supports the underlying assumption of the *Frequency-Lag hypothesis* by which bilinguals do not categorically differ from monolinguals. Instead, a continuous measure, such as accumulated frequency of use captures the difference between the groups and can predict TOT rates.

As objective measures of Hebrew proficiency were not collected, it may be argued that the difference between the two bilingual groups arises from differences in their L2 (Hebrew) proficiency. Indeed, the lower "GOT" rates and higher "Don'tknow" rates (see Table 2) for late compared to early bilinguals indicate that our late bilinguals are less proficient in their L2 than our early bilinguals. Notably, however, age of acquisition and frequency of L2 use could be viewed as inherently linked to L2 proficiency. Nonetheless, to address such concerns, TOT rates were calculated as the proportion of the total number of words that each participant knew ("TOT" + "GOT"), excluding unknown words. Consequently the difference between the two bilingual groups cannot be explained as merely reflecting their vocabulary knowledge.

In contrast to previous studies (Gollan & Acenas, 2004; Gollan et al., 2005), in the current study early bilinguals did not differ from the control group in TOT rates at baseline prior to non-target language exposure. This may be explained by two differences between the current study and previous research. First, due to sociolinguistic processes associated with immigration, the early bilingual speakers in the current study were integrated into the Hebrew speaking society such that their two languages were used less interchangeably than for early bilinguals in previous studies (e.g., Spanish–English, Gollan & Acenas, 2004). Second, participants in the control group of the current study were not purely monolinguals in that they were somewhat proficient in English (as were the experimental bilingual groups). It is possible that early bilinguals would have diverged from a control group of pure monolinguals. However, as bi- and multi-lingualism becomes more and more ubiquitous, comparisons of participants from different points on the multilingualism continuum are relevant to consider.

4.2. Short-term experience and TOT

The current study goes beyond previous research to show that TOT rates can also be modulated by short-term experience such as recent, brief exposure to the non-target language, even when this exposure does not include the translations of target items. Specifically, TOT rates increased following a brief (10 min) movie in the non-target language. The early and late bilinguals showed an increase of similar magnitude, whereas the native Hebrew speakers showed a much smaller increase in TOT rates following the same Russian movie. Critically, unlike most previous research that demonstrated short-term cross-language effects of item-based interference (e.g., Gollan et al., 2014; Misra et al., 2012; but see Elston-Güttler et al., 2005), the findings presented here reveal a global effect that cannot be associated with exposure to specific items, their translation or related words.

The *Frequency-Lag Hypothesis* explains bilinguals' increased TOT rates compared to monolinguals as emerging from weaker links in the bilingual lexical system, which in turn lead to increased difficulty in retrieving words. This mechanism is assumed to operate differentially on different items depending on their frequency of use, as demonstrated by the findings that items which are identical in both languages (i.e., cognates and proper names) differ from other items in that they do not elicit increased TOT rates for bilinguals compared to monolinguals (Gollan & Acenas, 2004; Gollan et al., 2005). Thus, while this mechanism provides a good account for the

effect of long-term language experience with variable types of items, it cannot explain the effect of brief recent exposure to non-target language that does not include the target items, because this effect must arise from global rather than item-related processes.

The *dual-language activation account* offers a mechanism that can account for such global exposure effects. Specifically, this approach emphasizes the co-activation of the different languages of bilingual speakers, which may be enhanced by recent exposure to one language. According to this view, exposure to the Russian movie may have changed the activation balance of the two languages in one of two ways. First, recent exposure may have increased the activation level of Russian such that Russian served as a more efficient competitor during subsequent Hebrew production (for relevant discussion, see Van Assche et al., 2013). Alternatively, or additionally, Russian exposure may have led to inhibition of Hebrew, such that on subsequent Hebrew use participants had to recover from inhibition (Green, 1998; Kroll, Bobb, Misra, & Guo, 2008). In either case, to explain global effects of the type observed in the current study, the *Dual-Language Activation* account must assume a dynamic system in which a change in activation balance may occur at a whole-language level as suggested by Van Assche et al. (2013), but competition and selection for production may occur at different stages of production. One instantiation of such a mechanism, relevant to the current findings, may involve a change of activation balance in sub-lexical phonological components following the brief exposure to non-target language, which in turn would enhance interference at the production stages involving phonological planning or even articulation. Because there is a limited set of phonological representations, even a short movie with no direct exposure to target lexical items may change the activation level of the entire phonological set thereby invoking a global effect.

Furthermore, the findings of the current study are novel in showing that passive exposure to the non-target language in a comprehension task influenced performance in production. These findings indicate that cross-language interference operates across language modality and suggest that lexical access in comprehension and production rely on shared representations and mechanisms.

An unexpected finding that emerged in the current study was that native Hebrew speakers exhibited increased TOT rates following exposure to Russian. This increase was smaller (1.3) than that of the bilingual speakers (early bilinguals 3.5; late bilinguals 4.6), but was evident nonetheless. Two possible explanations could account for this novel finding. The first is that domain general cognitive faculties such as attention or fatigue (e.g., Burke, MacKay, Worthley, & Wade, 1991), contribute to the increase in TOT rates. The second explanation assumes that although participants in the control group had no proficiency in the non-target exposure language, the effect is nevertheless language related. To examine these contrasting explanations we conducted the follow-up experiment with a different group of native Hebrew speakers who were exposed to a comparable movie in Hebrew. This experiment showed that following exposure to their native language participants did not experience increased TOT rates compared to their pre-exposure baseline. Pending replication, this finding suggests that the increase in TOT rate observed in the main experiment reported here is genuinely language related.

If this is the case, then the increase in TOT rates for participants who do not know the exposure language can serve to constrain the theoretical explanation of the entire set of findings. Specifically, because these participants do not know Russian, it is unlikely that brief exposure to such a foreign language would increase its activation and make it an effective competitor during subsequent production of the target language. Instead, this finding suggests that exposure to the non-target language lead to inhibition of the target language and therefore subsequent production in that target language suffered a decrement. Inhibition of the target language is expected to be more effective when participants know the non-target language, as was the case for the Russian–Hebrew bilinguals. More effective inhibition would be required in order to allow more engagement and more elaborate linguistic processing during comprehension of the non-target language. Thus, one can think of the effect of exposure to an unfamiliar language as triggering a general bilingual mode (Grosjean, 2001) that leads speakers to inhibit activation in the native language system and consequently increase production difficulties.[2] The current data cannot rule out the possibility that different mechanisms operate when the non-target language is familiar, as it was for the experimental groups, and when it is totally unfamiliar as it was for the control group. Although a parsimonious account would put the emphasis on target language inhibition (see also Misra et al., 2012), an alternative account may argue that when both languages are known increased activation of one language entails decreased activation in the other. Future research that will use more sensitive measures such as reaction-time and ERP in addition to TOT rates may shed some more light on this debated issue.

Finally, while the TOT rates reported in the current study are well within the range of TOT rates reported in the literature of bilingual TOT in laboratory studies (for an overview see Table 2 in Gollan & Brown, 2006), they are clearly higher than naturally occurring TOTs as reported in diary studies (e.g., Burke et al., 1991; Gollan et al., 2005). One salient reason is that laboratory picture naming tasks deprive the producer from contextual information that may facilitate lexical access. In addition, to elicit enough TOTs, laboratory studies typically select items with medium to low frequency, whereas mostly high frequency words are used in natural production. Despite these methodological differences, diary TOT studies find comparable group differences (e.g., Gollan et al., 2005), strengthening the ecological validity of laboratory studies of the type employed here. Laboratory studies have important advantages, for example, they allow controlled manipulation of factors such as the brief exposure examined here. Furthermore, in such a controlled setting one can record not only TOT incidents but also the complementary

[2] We thank Wouter Duyck and an anonymous reviewer for these interesting suggestions.

"GOT" and "don't know" responses. Increased TOT rates in the current study were consistently associated with decreased "GOT" rates for both group differences and context (before–after the movie) differences. This pattern is consistent with previous findings (e.g., Gollan et al., 2014) suggesting that increased TOT rates arise from increased difficulty in production rather than from facilitated ability to get out of the pre-TOT failure.

4.3. Conclusion

The results presented here highlight the dynamic nature of the bilingual system. Factors that operate on different time scales exert their influence on bilingual production, such that both long-term language experience and brief recent experience with the non-target language modulate production in the target language in a global, non-item-specific, manner. We discussed above two general accounts that may explain increased TOT rates and argued that each of these proposes a mechanism that accounts for one aspect of the findings, but cannot explain all the findings. The *Frequency-Lag* hypothesis accounts for group differences associated with life-long language experience, but cannot account for global cross- language effects. By contrast, the dual-activation account explains global cross-language effects, but cannot explain bilinguals' higher TOT rates in words they know in just one of their languages (Gollan & Acenas, 2004). While these two accounts have been often considered as competing, they seem to offer complementary explanations that can be integrated.

We propose an integrated account which incorporates mechanisms from both accounts and assumes that they operate on different time-scales and potentially on different levels of representation. One mechanism adjusts the strength of connections between lexical units based on their accumulated frequency of use, while the other adjusts the activation balance of the different languages and is more sensitive to contextual factors such as the task demands and language exposure and shifts. While the first mechanism operates at the lexical level, the second mechanism is more dynamic such that it can easily adjust to contextual changes. Combining these mechanisms into an integrated account allows us to explain the complex findings related to production difficulties, and in particular TOT, experienced by bilingual speakers.

Further research is required to elaborate this integrated account and explore the scope of bilingual effects it can explain. For example the limits of the global effects demonstrated here need to be specified by further research. Specifically, future studies may explore whether these effects operate in a bidirectional way, such that passive brief exposure to L2 can globally influence L1 production. In addition future research should examine whether such effects extend beyond the lexico-semantic system, to influence phonology or syntactic processes.

The current findings extend previous research on bilingual production by documenting group differences between early and late bilinguals in TOT rates. The findings further show that brief exposure to the non-target language increases TOT rates. This result is particularly interesting with regard to early bilinguals who seemed to perform in their L2 like native speakers prior to exposure to L1, but were nonetheless susceptible to the detrimental effect of brief L1 exposure to the same extent as late bilinguals. This finding highlights the critical relevance of language context to bilingual performance. Exploring the contribution of factors that operate on both long and short time-scales to bilinguals' performance will further elucidate our understanding of their ability to shift from one language to another.

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