

Supplementary Material Online:

Appendix A: Descriptions of the predictors considered in this study

Japanese-English-bilingual-specific lexical predictors. Phonological similarity (*PhonologicalSimilarityJPN*) is a rated cross-language phonological similarity measure obtained by 10 Japanese speakers. Participants completed, in a spread sheet, phonological similarity between English words (1st column) and Japanese words (2nd column), using a 7-point scale. In order to safeguard *PhonologicalSimilarityJPN* from potential confound arising from other lexical knowledge, we also considered objective Levenshtein distance coding phonological similarity (*PhonologicalDistance*). *PhonologicalDistance* gauges the number of operations required to transform Japanese words into the corresponding English translation equivalents in their phonologically transcribed form (Levenshtein, 1966; Yarkoni, Balota, & Yap, 2008; Dijkstra et al., 2010; Gooskens & Heeringa, 2004; Schepens, Dijkstra, & Grootjen, 2011; Schepens, Dijkstra, Grootjen, & van Heuven, 2013) based on the `sdists` function available in the R package `cba` (Buchta & Hahsler, 2009). In order to compare words of different lengths, we normalized the phonological Levenshtein distance based on the length of target English words ($M = 4.3$, $SD = 1.4$).

SemanticSimilarity was based on 10 Japanese-English bilingual readers' ratings on cross-language conceptual similarity. English and Japanese words were presented to the raters side-by-side in two columns in a spreadsheet (English words in the 1st column and Japanese words in the 2nd column). Using a seven-point scale (1 = very different, 7 = identical), the raters assessed the extent to which *katakana* loanwords in Japanese were

similar in meaning to the corresponding English target words and whether any Japanese katakana words were completely unfamiliar to them.

FreqJPN reflected how many times Japanese *katakana* words appeared in a Japanese newspaper corpus containing over three million words and covering the 14-year period from 1985 to 1998 (Amano & Kondo, 2003). *FreqJPN* was log-transformed, as its distribution had a long right tail. Note that it is often also possible to translate English words to logographic *kanji* or moraic *kana* words, as well as *katakana* loanwords. However, because the log-transformed frequency of *kanji* or *kana* translations obtained from the same corpus was not a significant predictor, we do not further discuss it.

Although *FreqJPN* comprises two distributions due to zero frequency of occurrence for some words, the corresponding log-transformed Google document frequency measure (*GoogleFreqJPN*) does not indicate such qualitative difference among the set of *katakana* words (see Appendix B). This suggests that the zero frequencies in *FreqJPN* are not due to qualitative differences with respect to words' lexical status, such as transliterations and translations, but due to the fact that the written word corpus is conservative for the purpose of the present study (i.e., it provides frequency counts for *katakana* words only up to the year 1998 and only in the context of newspaper texts).

Finally, a factor *Cognate* (levels: *Cognate* and *NotCognate*) was considered in addition to the above mentioned numerical predictors. Because considerable semantic and phonological overlap and sufficient exposure to words are expected for such special cognate representations to emerge in the first place, words with larger-than-the-average values in all *FreqJPN*, *PhonologicalSimilarityJPN*, and the conceptual similarity were categorized into *Cognate* ($N = 58$).

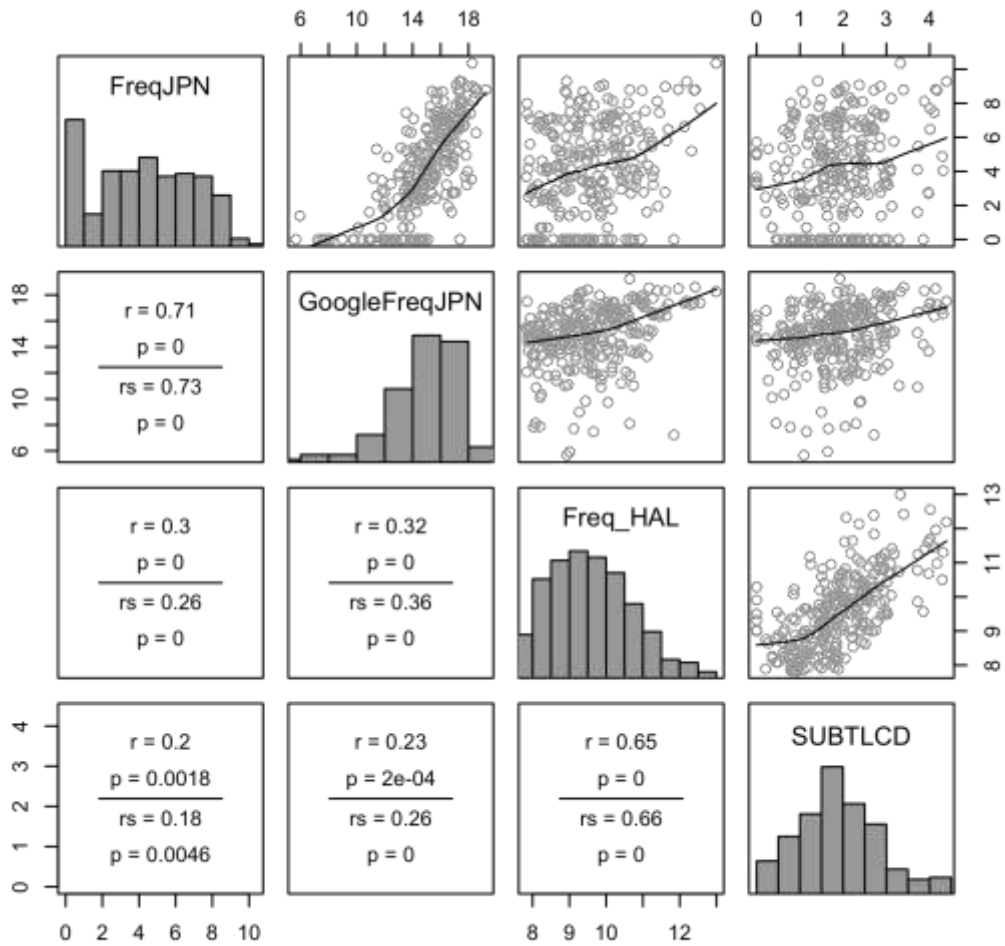
Lexical distributional predictors of the target English words. As orthographic predictors, we considered word length (*Length*) and orthographic Levenshtein distance (*OLD20*, Yarkoni et al., 2008). A low *OLD20* score indicates that a given word is located within a dense orthographic space. To measure English word frequency, we used log-transformed *FreqHAL* (HAL: Hyperspace Analogue to Language, Lund & Burgess, 1996; Burgess, & Livesay, 1998, as available in Balota et al., 2007). *SUBTLCD* is a log-transformed context diversity measure based on a number of films in which a given word had been used (Adelman, Brown, & Quesada, 2006; Brysbaert & New, 2009a, 2009b). We also considered ratings of word *Imageability*. Because *SemanticSimilarity* is expected to vary with imageability, with a larger cross-linguistic variance for abstract concepts relative to concrete concepts, *Imageability* safeguards our rated *SemanticSimilarity* measure. We obtained *Imageability* scores rated by 10 native English readers, using a seven-point scale (1 = not imageable, 7 = very imageable).

Task-related predictors and individual differences. In the response time analyses, we considered the following variables: *PreviousRT*, inversely transformed RT in the previous trial; *Trial*, the number of preceding trials; and *PreviousResponseCorrect*, whether the responses in the preceding two trials were correct (see Baayen & Millin, 2010 for autocorrelation in the time-series of response times). In the eye-movement analyses, we also considered *PreviousFixationDuration* for second fixation duration analyses to account for potential spillover effects from the previous fixation. *PreviousRT*, *Trial*, and *PreviousResponseCorrect* were also considered in the eye-movement analyses.

Consideration of readers' L2 proficiency is also important because such individual differences potentially lead to distinct processing mechanisms (Kroll & Stewart, 1994;

Potter, So, von Eckhardt, & Feldman, 1984). In our sample, we considered log-transformed participants' months of stay away from Japan for each participant (*LengthOfStayCanada*) in our regression analyses as a measure of L2 English proficiency. *LengthOfStayCanada* naturally brings in several other components of language proficiency; it highly correlated with age ($r = .68, p = .001$), with their vocabulary size in English measured by X_Lex The Swansea Levels Test (Meara, 2005, $r = .48, p = .03$). We leave the specific advantages and disadvantages of other related measures to future research.

Appendix B: A matrix of scatterplots for Japanese and English frequencies.



Appendix C: A residualization procedure

In order to study independent contributions of lexical distributional properties, we opted for a residualization procedure to resolve multicollinearities. For example, *OLD20* highly correlates with *Length*, *SUBTLCD*, and the number of meanings in WordNet (Miller, 1990). *OLD20* was therefore regressed on these three variables, and the residuals were used as a new predictor *OLD20_resid*. The new predictor correlated significantly and strongly with the original predictor ($r = .67, p < .01$ with *OLD20*). To safeguard our measures, the same residualization procedure was applied to the following variables with highly significant inter-correlations: *SUBTLCD* (regressed on *FreqHAL* and a number of meanings); *Imageability* (regressed on *FreqHAL*, *Length*, number of meanings); *FreqJPN* (regressed on *FreqHAL*, *SUBTLCD*, and number of meanings); *SemanticSimilarity* (regressed on *FreqJPN* and *GoogleFreqJPN*). After the residualization procedure, all the new predictors correlated significantly with the respective original predictors: $r = .67$ for *OLD20_resid* and *OLD20*, $r = .75$ for *SUBTLCD_resid* and *SUBTLCD*, and $r = .95$ for *FreqJPN_resid* and *FreqJPN*. *GoogleFreqJPN* and *PhonologicalDistance* were not included in statistical models together with *FreqJPN* and *PhonologicalSimilarityJPN* but considered separately to assess whether the pattern of results remains unchanged when one predictor is replaced with another. Task-related variables *PreviousRT* and *FirstSubgazeDuration* were similarly regressed on correlated predictors (*Trial* for the former and *Trial*, *PreviousRT*, *FreqHAL*, *Length*, and *SUBTLCD* for the latter), resulting in *PreviousRT_resid* and *FirstSubgazeDuration_resid*.

Appendix D: Materials used in this study

English words used in the present study and their Japanese *katakana* translation and phonology. The flap /ɾ/ was used to encode English approximants /r/ and /l/. /ɸ/ represents a voiceless bilabial fricative. Vowels and consonants were repeated in the Japanese phonological transcriptions to encode the Japanese-specific moraic long vowels, moraic nasals, and moraic obstruents. Words marked with * were excluded from the analyses.

English word	Japanese katakana	Japanese phonology	English word	Japanese katakana	Japanese phonology
accent	アクセント	akusennto	lesson	レッスン	ɾessunn
account	アカウント	akaunnto	letter	レター	ɾetaa
advance	アドバンス	adobannsu	library	ライブラリー	ɾaibuɾaɾii
advantage	アドバンテージ	adobannteedzi	license	ライセンス	ɾaisennsu
advice	アドバイス	adobaisu	magazine	マガジン	magadzinn
agenda	アジェンダ	adzennnda	manifest	マニフェスト	maniɸesuto
amateur*	アマチュア	amatɕua	manner	マナー	manaa
anchor	アンカー	annkaa	marble	マーブル	maabuɾu
answer	アンサー	anssaa	margin	マージン	maadzinn
appeal	アピール	apiiɾu	massage	マッサージ	massaadzi
arcade*	アーケード	aakeedo	matrix	マトリックス	matotɾikkusu
architect	アーキテクト	aakitekuto	measure	メジャー	medzaa
aspect	アспект	asupekuto	medicine	メディスン	medisunn
attempt	アテンプト	atemmputo	merchant	マーチャント	maatɕannto
auction	オークション	ookuɸonn	message	メッセージ	messeedzi
autumn	オータム	ootamu	method	メソッド	mesoddo
avenue	アベニュー	abenjuu	minister	ミニスター	minisutaa
balloon	バルーン	baɾuunn	miracle	ミラクル	miɾakuɾu
ballot*	バロット	baɾotto	mirror	ミラー	miɾaa
basket	バスケット	basuketto	mission	ミッション	miɸɸonn
blanket	ブランケット	buɾannketto	moment	モーメント	moomennto
bottom	ボトム	botomu	monster	モンスター	monnsutaa
bracket	ブラケット	buɾaketto	morning	モーニング	mooninɲgu
breast	ブレスト	buɾesuto	motion	モーション	mooɸonn
breath	ブレス	buɾesu	mountain	マウンテン	maunntenn
bronze	ブロンズ	buɾonnzuz	muscle	マッスル	massuɾu
buffalo	バッファロー	baɸɸaɾoo	museum	ミュージアム	mjuudziamu
buffer	バッファー	baɸɸaa	nature	ネーチャー	neetɕaa
bullet	ブレット	buɾetto	needle	ニードル	niidoɾu
bulletin	ブリテン	buɾitenn	notice	ノーティス	nootisu

bundle	バンドル	banndoꝛu	notion	ノーション	noofonn
burden	バードン	baadonn	number	ナンバー	nammbaa
business	ビジネス	bidzinesu	occasion	オケーション	okeefonn
butter	バター	bataa	office	オフィス	oφisu
cabinet	キャビネット	kjabinetto	opinion	オピニオン	opinionn
camera	カメラ	kameɾa	opponent	オポネント	opoonennto
candle	キャンドル	kjanndoꝛu	option	オプション	opuɟonn
cannon	キャノン	kjanonn	palace	パレス	paɾesu
career	キャリア	kjaɾia	parade	パレード	paɾeedo
cartoon	カートゥーン	kaatuunn	paradise	パラダイス	paɾadaisu
castle	キャッスル	kjassuɾu	paradox	パラドックス	paɾadokkusu
catalog	カタログ	kataɾogu	pencil	ペンシル	pennɟiɾu
cathedral*	キャシードラル	kjaɟiidoraɾu	peninsula*	ペニンスラ	peninnsuɾa
cattle	キャトル	kjatoɾu	period	ピリオド	piɾiodo
ceiling*	シーリング	ɟiɾiɾiŋgu	personnel	パーソネル	paasoneru
century	センチュリー	senntɟuɾii	phantom	ファントム	φanntomu
challenge	チャレンジ	tɟaɾennɟzi	planet	プラネット	puɾanetto
champion	チャンピオン	tɟammpionn	plastic	プラスチック	puɾasutɟikku
chance	チャンス	tɟannsu	pocket	ポケット	poketto
channel	チャンネル	tɟannneɾu	poison	ポイズン	poizunn
chapter	チャプター	tɟaputaa	police	ポリス	poɾisu
character	キャラクター	kjaɾakutaa	politics	ポリティクス	poɾitikkusuu
charter	チャーター	tɟaataa	poverty	パーバティー	paabatii
cherry	チェリー	tɟeɾii	priest	プリースト	puɾiisuto
chocolate	チョコレート	tɟokoɾeeto	prince	プリンス	puɾinnsu
church	チャーチ	tɟaatɟi	principle	プリンシプル	puɾinnɟipuɾu
circuit*	サーキット	saakitto	prison	プリズン	puɾizunn
circus	サーカス	saakasu	privilege	ブリビレッジ	puɾibiɾeddzi
cluster	クラスター	kuɾasutaa	profile	プロフィール	puɾoφiiɾu
college	カレッジ	kaɾeddzi	program	プログラム	puɾoguɾamu
comment	コメント	komennto	promise	プロミス	puɾomisu
complaint	コンプレイント	kommpuɾeinnto	protest	プロテスト	puɾotesuto
component	コンポーネント	kommponennto	rabbit	ラビット	ɾabbitto
condition	コンディション	konndiɟonn	receipt	レシート	ɾeɟiito
conflict	コンフリクト	konnφuɾikuto	recipe	レシピ	ɾeɟipi
content	コンテンツ	konntennto	rescue	レスキュー	ɾesukjuu
corner	コーナー	koonaa	result	リザルト	ɾizaɾuto
couple	カップル	kappuɾu	rocket	ロケット	ɾoketto
course	コース	koosu	salary	サラリー	saɾaɾii
courtesy*	カーテシー	kaateɟii	sample	サンプル	sammpuɾu
credit	クレジット	kuɾedzitto	satellite*	サテライト	sateɾaito
crystal	クリスタル	kuɾisutaɾu	scheme*	スキーム	sukiimu
culture	カルチャー	kaɾutɟaa	school	スクール	sukuuɾu

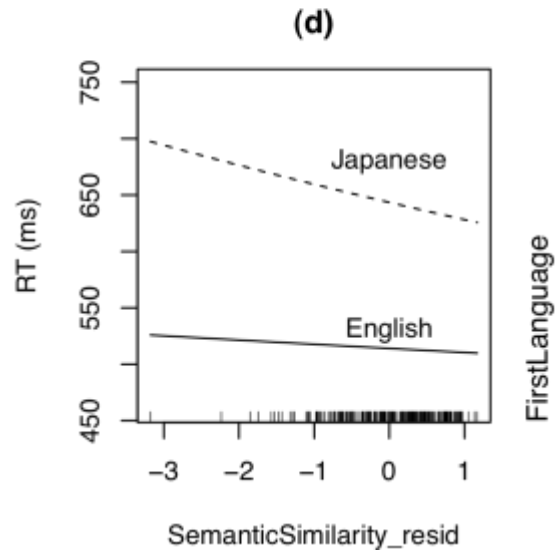
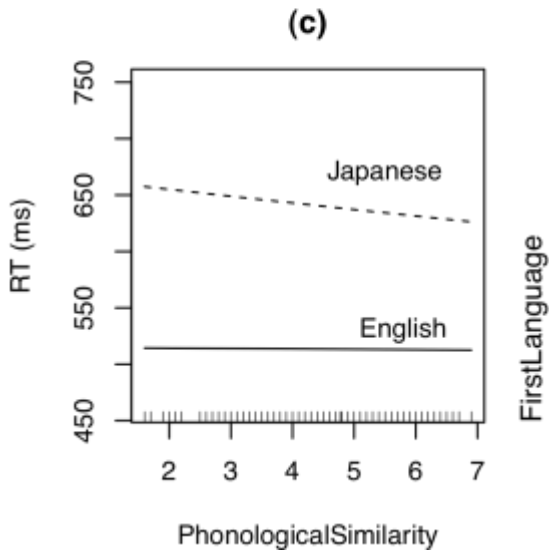
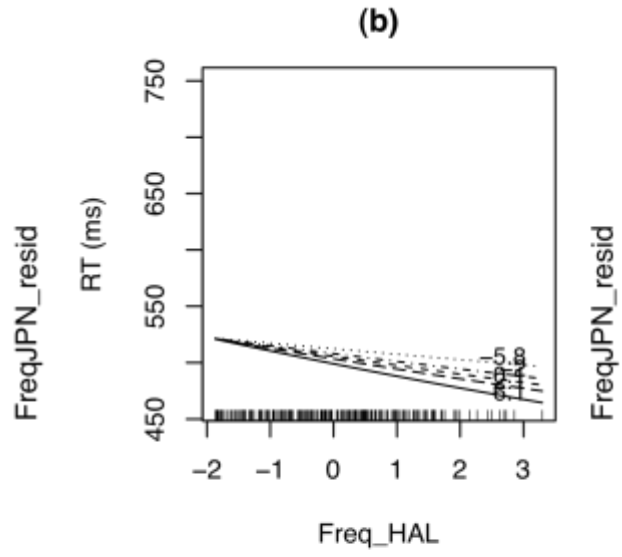
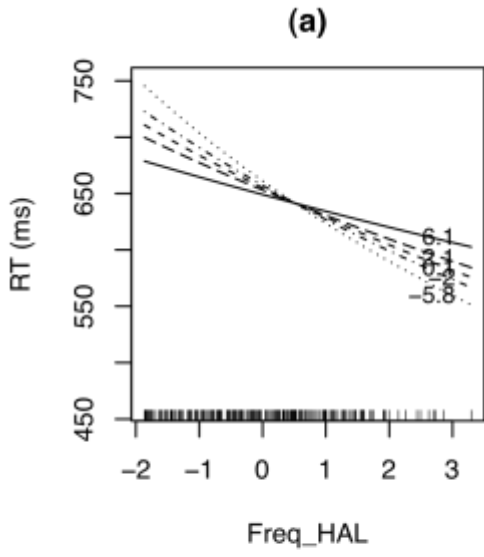
damage	ダメージ	dameedzi	search	サーチ	saatʃi
danger	デンジャー	denndʒaa	secretary	セクレタリー	sekuʃetaɾii
debate	ディベート	dibeeto	sentence	センテンス	senntennsu
defense	ディフェンス	diʃennsu	session	セッション	seʃʃonn
degree	ディグリー	diguɾii	shadow	シャドー	ʃadoo
design	デザイン	dezainn	shield*	シールド	ʃiirudo
diagram	ダイアグラム	daiaguɾamu	soccer	サッカー	sakkaa
diamond	ダイヤモンド	daiamonndo	socket	ソケット	soketto
dilemma*	ジレンマ	dziɾennma	soldier	ソルジャー	soɾudʒaa
disaster	ディザスター	dizasutaa	source	ソース	soosu
disease	ディジーズ	didziizu	speech	スピーチ	supiitʃi
district	ディストリクト	disutoɾikuto	sponsor	スポンサー	suponnsaa
doctrine*	ドクトリン	dokutoɾinn	square	スクエア	sukuea
domain	ドメイン	domeinn	stance	スタンス	sutannsu
donkey	ドンキー	donɯkii	statue*	スタチュウ	sutatʃuu
dragon	ドラゴン	doɾagonn	status	ステータス	suteetasu
dungeon*	ダンジョン	dannɟonn	street	ストリート	sutoɾiito
effort	エフォート	eʃooto	strength	ストレングス	sutoɾennɡusu
elephant	エレファント	eɾeʃannto	string	ストリング	sutoɾiɯɯɡu
embassy	エンバシー	emmbaʃii	studio	スタジオ	sutadzio
emergency	イマージェンシー	imadzennʃii	summer	サマー	samaa
emperor*	エンペラー	emmpɾaa	surface	サーフェス	saaʃesu
episode	エピソード	episoodo	syndrome	シンドローム	ʃinndoɾoomu
example	エグザンプル	eguzamppuɾu	system	システム	ʃisutemu
expert	エキスパート	ekisupaato	talent	タレント	taɾennnto
fashion	ファッション	ʃaʃʃonn	target	ターゲット	taagetto
fatigue*	ファティーグ	ʃatiigu	technique	テクニク	tekunikku
fellow	フェロー	ʃeɾoo	template	テンプレート	temmpuɾeeto
finance	ファイナンス	ʃainansu	temple	テンプル	temmpuɾu
flavor	フレーバー	ʃuɾeebaa	territory	テリトリー	teɾitoɾii
flight	フライト	ʃuɾaito	texture	テクスチャ	tekusutʃa
friend	フレンド	ʃuɾennndo	theatre	シアター	ʃiataa
garbage	ガービッジ	gaabiddzi	thread	スレッド	suɾeddo
garlic*	ガーリック	gaaɾikku	threshold*	スレッシュホールド	suɾeʃʃuhooɾudo
gender	ジェンダー	dʒennndaa	toilet	トイレット	toiɾetto
grease*	グリース	ɡuɾiisu	traffic	トラフィック	toɾaʃikku
guitar	ギター	gitaa	tragedy	トラジェディー	toɾadzedii
hazard	ハザード	hazaado	treaty	トリーティー	toɾiitii
helmet	ヘルメット	heɾumetto	tunnel	トンネル	tonnneɾu
heroin*	ヘロイン	heɾoinn	twilight	トワイライト	towaiɾaito
horizon	ホライズン	hoɾaizunn	vanilla	バニラ	baniɾa
husband	ハズバンド	hazubanndo	vehicle	ビークル	biikuɾu
impact	インパクト	immpakuto	venture	ベンチャー	bennʃaa

incentive	インセンティブ	innsenntibu	version	バージョン	baadzonn
industry	インダストリー	inndasutoꝛii	veteran*	ベテラン	beteꝛann
insect	インセクト	innsekuto	village	ビレッジ	biꝛeddzi
instinct	インスティンクト	innsutinnkuto	violin	バイオリン	baioꝛinn
interest	インタレスト	inntaꝛesuto	vitamin	ビタミン	bitaminn
interval	インターバル	inntaabaꝛu	volume	ボリューム	boꝛjuumu
interview	インタビュー	inntabjuu	weather	ウェザー	wezaa
jacket	ジャケット	dzaketto	whistle	ホイッスル	hoissuꝛu
leisure	レジャー	ꝛedzaa	witness	ウィットネス	wittonesu

Appendix E: A direct comparison between monolinguals and bilinguals

Estimate, standard error, t-value, p-value, and effect size (ms) of the fixed effects in the model of Japanese-English bilinguals and English monolingual readers' lexical decision response times analyzed together for a direct comparison of the two groups.

Response time	Type	Estimate	Std.Error	t-value	p-value	Effect size
(Intercept)		-1.910	0.044	-43.72	< .0001	
PreviousResponseCorrect (Error)	Task	0.065	0.009	7.23	< .0001	17
Trial	Task	-0.054	0.006	-8.79	< .0001	-63
PreviousRT	Task	0.158	0.014	11.67	< .0001	115
FirstLanguage (Japanese)	Individual	0.456	0.054	8.39	< .0001	127
Length	Engl	0.030	0.008	3.90	.0001	24
FreqHAL	Engl	-0.031	0.007	-4.45	< .0001	-41
SUBTLCD_resid	Engl	-0.059	0.008	-6.99	< .0001	-66
Imageability_resid	Engl	-0.009	0.004	-1.94	.0520	-14
FreqJPN_resid	Jpn-Engl	-0.004	0.003	-1.77	.0763	-13
PhonologicalSimilarity	Jpn-Engl	-0.001	0.006	-0.22	.8282	-2
SemanticSimilarity_resid	Jpn-Engl	-0.014	0.011	-1.31	.1901	-16
Length	Engl					66 (Jpn)
* FirstLanguage (Japanese)	* Individual	0.019	0.007	2.69	.0071	24 (Engl)
Imageability_resid	Engl					15 (Jpn)
* FirstLanguage (Japanese)	* Individual	0.013	0.004	3.49	.0005	-14 (Engl)
Freq_HAL	Engl					-134 (Jpn)
* FirstLanguage (Japanese)	* Individual	-0.036	0.007	-5.01	< .0001	-41 (Engl)
FreqJPN_resid	Jpn-Engl					-17 (Jpn)
* FirstLanguage (Japanese)	* Individual	0.001	0.002	0.64	.5223	-14 (Engl)
FreqHAL	Engl					Appendix C
* FreqJPN_resid	* Jpn-Engl	-0.002	0.002	-0.70	.4828	(a, b)
FreqHAL	Engl					Appendix C
* FreqJPN_resid	* Jpn-Engl					(a, b)
* FirstLanguage (Japanese)	* Individual	0.007	0.002	3.38	.0007	(a, b)
PhonologicalSimilarity	Jpn-Engl					Appendix C
* FirstLanguage (Japanese)	* Individual	-0.013	0.005	-2.56	.0105	(c)
SemanticSimilarity_resid	Jpn-Engl					Appendix C
* FirstLanguage (Japanese)	* Individual	-0.024	0.009	-2.70	.0070	(d)



Appendix F: Re-consideration of rated measures

As in many past studies, the present study relied on human rated measures. However, there are many different ways to obtain rated measures, and there is no consensus as to what best simulates on-line processing. The figure below summarizes the cross-language similarity measures in phonology and semantics (indicated by solid and dotted lines respectively).

In this study, the objective edit distance measure (*PhonologicalDistance*) replicated the late effect, but not early effects, of the rated *PhonologicalSimilarityJPN* successfully. This may be due to Japanese-English late bilinguals' incomplete mental phonological representations of English words, which was not assumed for *PhonologicalDistance*. When a rated phonological similarity based on an assessment by 10 native English speakers was considered (*PhonologicalSimilarityENGL*, $M = 4.3$, $SD = 1.1$), this variable behaved much like the objective *PhonologicalDistance* albeit the fact that *PhonologicalSimilarityENGL* correlated with *PhonologicalSimilarityJPN* ($r = .63$, $p < .01$) more strongly than *PhonologicalDistance* ($r = .40$, $p < .01$). In the *PhonologicalSimilarityENGL* rating task, the English speakers saw English words on a computer display, while they heard corresponding Japanese words recorded by a native female Japanese reader.

Similarly, there are different ways to rate cross-language *SemanticSimilarity*. A reviewer pointed out that the result might be different if semantic similarity is rated in the reversed direction (i.e., Japanese words in the first column and English words in the second column). We therefore collected ratings from 9 Japanese-English bilinguals (*SemanticSimilarityReversed*). This new measure correlates with *SemanticSimilarity*

largely ($r = .73, p < .01$) and replicated the semantic similarity effects (with an interaction with *PreviousRT*) in response time and last fixation duration analyses.

