TESIS DOCTORAL

INHIBITORY CONTROL IN BILINGUALISM

(Control inhibitorio en bilingüismo)

DOCTORADO INTERNACIONAL

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INHIBITORY CONTROL IN BILINGUALISM

Tesis Doctoral presentada por **María Cruz Martín García** en el *Departamento de Psicología Experimental*, para aspirar al grado de Doctor en Psicología, en el programa de doctorado de *Psicología Experimental y Neurociencias del Comportamiento*, de la Universidad de Granada.

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La doctoranda

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A mi padre.

PUBLICACIONES DE LA TESIS

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CAPÍTULO I

INTRODUCCIÓN Y OBJETIVOS DE LA TESIS

PREFACIO

Aún recuerdo el tiempo compartido de mi niñez en familia, una familia muy especial que ante mis ojos de niña se me presentaba como un fenómeno un tanto particular. Mis primos habían nacido en Suiza, en el cantón alemán, y, además de otras cosas, lo que tenían de especial era tener una madre española, un padre italiano y haber recibido una educación en alemán. Era todo un acontecimiento la llegada de las vacaciones de verano, tiempo que compartíamos, bien en Suiza, bien en España. Yo los miraba atónita cuando hablaban con sus amigos en aquella lengua endiablada que yo no entendía. Era divertido jugar a conocer palabras nuevas en alemán (y las diferencias de pronunciación en su correspondiente dialecto, además). Y yo aprendía: eins, zwei, drei…; o: weiβ, rot, grün, schwartz... Pero a veces también cambiábamos al italiano: uno, due, tre…; o: bianco, rosso, verde, nero… También me llamaba la atención lo deprisa que hablaban en alemán y lo despacio que hablaban en español. Y su escaso vocabulario en castellano, que compensaban con algún que otro vocablo en italiano (ahora me doy cuenta de que muchos de ellos eran palabras cognadas). Claramente su lengua dominante (L1) era el alemán, que usaban a la par que el español y el italiano (su segunda y tercera lengua, L2 y L3, respectivamente). Por eso, a veces preferían hablar en alemán con su madre e incluso con su padre, y aunque empezasen una conversación en español, terminaban hablando en alemán. Quizá también porque su madre, aun siendo nativa del español, estaba inmersa en su segunda lengua, el alemán (como veremos más adelante, la inmersión en una segunda lengua puede afectar a la forma en que se procesa la primera lengua) (Linck, Kroll y Sunderman, 2009).

Pero la situación se invertía aquellos veranos en los que venían a España. Entonces eran ellos los que empezaban a tener una experiencia de inmersión en su L2, el español. Ahora era yo la que explicaba significados, corregía tiempos verbales, y respondía con la palabra adecuada ante las incursiones del italiano. Ni que decir tiene que aquel tiempo de verano compartido era toda una experiencia de aprendizaje, y aunque se trate simplemente de una anécdota personal, sirva para ilustrar una realidad patente de nuestros días y que tiene mucho (o todo) que ver con el tema del presente trabajo de investigación: el hecho de que gran parte de la población del mundo hoy en día habla y comprende dos o más lenguas.

Como para mis primos, para muchos bilingües el hecho de usar más de una lengua y cambiar de una a otra cuando la situación lo requiere es algo habitual. Pero aunque para un bilingüe es posible interaccionar con otras personas en el idioma que la situación requiere sin confusión acerca de cuál es el idioma que tiene que elegir, la evidencia empírica sugiere que ambas lenguas están activas cuando la persona bilingüe se enfrenta a tareas de comprensión o producción (Dijkstra, 2005; Kroll, Bobb y Wodniecka, 2006; Marian y Spivey, 2003). El hecho de que ambas lenguas estén activas, aun usando sólo una de ellas, supone que puede producirse una mutua influencia entre ellas, pudiendo afectar a la ejecución del bilingüe en la lengua en uso. Esta influencia entre las lenguas activas del bilingüe puede en unos casos facilitar la ejecución, pero en otros casos ésta puede verse perjudicada, llevando al bilingüe a una ejecución más lenta y con mayor tendencia a la comisión de errores (Dijkstra, 2005). Si esto es así, cabe preguntarse cómo consigue un bilingüe tener control sobre sus dos lenguas activas y seleccionar con éxito la que necesita.

Por ejemplo, cuando mis primos escuchaban la palabra "*burro*", probablemente interpretaran que se trataba de un animal si era su madre la que estaba hablando (contexto español), pero pensarían en mantequilla si la conversación la mantenían con su padre (contexto italiano). Pero probablemente, aunque su interpretación fuera correcta en ambos casos, experimentarían, aun sin ser conscientes de ello, cierto grado de interferencia entre ambas representaciones, y resolverían la competición generada mediante un mecanismo de control cognitivo que les ayudaría a seleccionar el significado correcto en cada caso.

La exposición a situaciones lingüísticas en las que la activación paralela de ambas lenguas requiere del control cognitivo para la selección de una de ellas, hace que los bilingües desarrollen una habilidad cognitiva que les permite manejar el control de la activación de las lenguas con facilidad. Actualmente existe una importante línea de investigación que centra su foco de atención en las consecuencias que puede tener la práctica en la experiencia bilingüe sobre el sistema cognitivo, y en particular en la función ejecutiva. Hoy en día un gran número de estudios sugiere que la experiencia como bilingüe no sólo aumentaría la competencia lingüística sino que también conferiría ventajas en procesos de control cognitivo implicados en tareas no lingüísticas que requieren de resolución de conflicto (Bialystok, 2007; Bialystok y Craik, 2010). En relación a los beneficios que puede proporcionar la experiencia como bilingüe, estudios recientes muestran que los niños que han sido educados en un ambiente bilingüe desarrollan diversos beneficios a nivel cognitivo durante la infancia (Bialystok, 2010; Bialystok y Martin, 2004) y además el bilingüismo parece dotar de cierto grado de protección contra los síntomas de la enfermedad de Alzheimer en personas mayores (Bialystok, Craik y Freedman, 2007; Craik, Bialystok y Freedman, 2010; Schweizer, Ware, Fisher, Craik y Bialystok, en prensa).

Son numerosos los temas de interés en la investigación en relación al bilingüismo que se han abordado tradicionalmente desde la psicolingüística y más recientemente desde la neurociencia cognitiva. En el presente trabajo de investigación trataremos de profundizar en algunos de ellos. En primer lugar, trataremos de examinar cómo alcanzan las personas bilingües el acceso al léxico requerido en condiciones de activación simultánea de ambas lenguas, prestando especial atención a los mecanismos de control implicados en la selección de idioma. En segundo lugar, profundizaremos en el estudio de un aspecto relacionado con la naturaleza de dichos procesos de control como es el curso temporal de los procesos inhibitorios. En tercer lugar, trataremos de observar los correlatos electrofisiológicos de la interferencia generada por la activación no selectiva de ambas lenguas y de la presencia de procesos de control en la resolución de la competición entre representaciones. Por último, centraremos nuestra atención en dos factores que pueden modular tanto los procesos de activación de idioma como los procesos de control en la selección de idioma en bilingües, como son la inmersión en un contexto de segunda lengua y la experiencia en tareas de traducción.

En el presente capítulo de introducción se incluye una revisión teórica general en relación a cada uno de los objetivos del presente trabajo de investigación. En un primer apartado, revisaremos las principales perspectivas teóricas sobre el procesamiento de idioma en bilingües que han intentando dar respuesta a cómo se produce el acceso léxico y cuáles son los mecanismos de control implicados en la selección de idioma. A continuación, revisaremos los principales estudios que han motivado la serie experimental relacionada con el curso temporal de los procesos inhibitorios en la selección de idioma. Seguidamente, incluiremos una breve introducción sobre los principales componentes cerebrales relacionados con distintos aspectos del procesamiento lingüístico en bilingües. Finalmente nos centraremos en los estudios previos realizados en relación a los factores moduladores del procesamiento bilingüe de interés para el presente trabajo, y terminaremos con un apartado final en el que ofreceremos una visión general de la organización y los objetivos de los estudios incluidos en esta tesis.

ACCESO LÉXICO EN BILINGÜES

Numerosas investigaciones han centrado su interés en el estudio de los procesos implicados en el aprendizaje y uso de una segunda lengua (L2) para llegar a comprender la forma en que las representaciones de la L2 se relacionan con las representaciones de la primera lengua (L1; Kroll y de Groot, 2005). A partir de los resultados de estos estudios se han puesto de manifiesto algunos aspectos de especial importancia en relación al procesamiento bilingüe. En primer lugar, se ha observado que cuando los bilingües competentes producen o comprenden la L2, de forma paralela también se activan representaciones de la L1 (ver Dijkstra, 2005, para una revisión). Derivado de esta activación no-selectiva, se han propuesto diferentes mecanismos para explicar la forma en que la persona bilingüe, finalmente, selecciona la lengua en que desea hablar (v.g., Green, 1998). En segundo lugar, se han observado diferencias en el acceso a las representaciones y regulación del sistema lingüístico de la persona bilingüe en función de una serie de factores que varían dependiendo de su nivel de aprendizaje y dominio de la L2, su experiencia en el uso de ambas lenguas, las demandas impuestas en una tarea determinada o el contexto en que se encuentra inmersa (Costa y Santesteban, 2004; Ibáñez, Macizo y Bajo, 2006; Kroll et al., 2006; Kroll y Stewart, 1994; Martín, Macizo y Bajo, enviado).

La mayoría de los estudios que han abordado la interacción entre ambos idiomas de la persona bilingüe han utilizado como estrategia general el uso de palabras en uno de los idiomas que comparten propiedades léxicas, ortográficas o fonológicas con palabras en el otro idioma (v.g., falsos amigos u homógrafos, cognados y homófonos). Por ejemplo, muchos estudios, a partir de tareas de nombrado o de decisión léxica, han mostrado que las palabras cognadas (i.e., palabras con el mismo significado y con total o parcial solapamiento ortográfico y fonológico en dos idiomas distintos, como por ejemplo *cebra*, en español, y *zebra*, en inglés) se reconocen o pronuncian más rápido que palabras control no cognadas existentes sólo en uno de los idiomas (i.e., *efecto de facilitación con cognados*; Costa, Caramazza y Sebastián-Gallés, 2000; Dijkstra, Grainger y Van Heuven, 1999; Lemhöfer y Dijkstra, 2004).

En la investigación sobre el procesamiento lingüístico en bilingües también se ha recurrido al uso de homógrafos entre lenguas como estrategia para abordar el estudio de la activación paralela de dos idiomas (Beauvillain y Grainger, 1987; De Groot, Delmaar y Lupker, 2000). Los homógrafos entre lenguas son palabras que se escriben de la misma forma pero tienen significados diferentes en los dos idiomas de la persona bilingüe (v.g., la palabra *pie* puede referirse a una parte del cuerpo en español o a una tarta en inglés). Cuando un homógrafo entre lenguas se reconoce más lentamente o más rápidamente que una palabra control igualada en propiedades lingüísticas, pero que existe sólo en uno de los idiomas del bilingüe, podemos pensar que se está produciendo algún tipo de influencia entre ambos idiomas. Si durante el procesamiento de una determinada palabra se activan los dos idiomas del bilingüe, ante un homógrafo entre lenguas se activarán ambos significados del homógrafo independientemente del contexto en que se presente.

Mientras que el efecto de facilitación con cognados se ha observado utilizando una amplia variedad de tareas diferentes, los efectos de interacción entre dos idiomas a partir del uso de homógrafos no han resultado ser tan consistentes. Así, dependiendo de la tarea y de las características léxicas de las palabras homógrafas, la activación no-selectiva de ambos idiomas podrá facilitar o perjudicar la ejecución (Dijkstra, Van Jaarsveld y Ten Brinke, 1998; Schwartz y Kroll, 2006; Von Studnitz y Green, 2002). Por ejemplo, Dijkstra et al. (1998) realizaron un estudio con bilingües de alemán/inglés. En uno de los experimentos del estudio (Experimento 3) se presentaban grupos de letras, ante los cuales los participantes tenían que decidir si se trataba de una palabra en inglés o en alemán. Los estímulos presentados podían ser palabras en alemán, palabras en inglés, homógrafos alemán/inglés o no-palabras. Los resultados mostraron que los participantes respondían más rápido ante los homógrafos que ante las palabras control. En este caso, la activación de los dos significados del homógrafo produjo una mejora en la ejecución de los participantes ya que la tarea requería el reconocimiento de palabras, independientemente del idioma en que se presentaban. Otros estudios, por el contrario, han encontrado que la activación de los dos significados del homógrafo dificulta la ejecución cuando la tarea requiere la activación de uno solo. De Groot et al., (2000) realizaron un estudio con homógrafos alemán/inglés utilizando una tarea en la que los participantes (bilingües de alemán/inglés) decidían si las traducciones de los pares de palabras que se les presentaban eran equivalentes o no. Cuando los pares de palabras contenían un homógrafo, los participantes mostraban tiempos de respuesta mayores en relación a los pares de palabras control. Por ejemplo, ante un par de palabras como *glad-slippery* (en el que la palabra *glad* significa “contento” en inglés y “resbaladizo” en alemán) la activación del significado irrelevante del homógrafo interfiere con el significado relevante del homógrafo sesgando a los participantes hacia una respuesta negativa y, por lo tanto, haciendo que la ejecución de la respuesta correcta sea más lenta.

Del conjunto de resultados expuestos anteriormente, se desprende que si ambos idiomas se activan de forma no-selectiva en un momento dado, podrían establecerse procesos de competición entre ambos. De esta forma, la producción lingüística en la L2 podría verse dificultada por la interferencia que se produce entre las dos lenguas. Una habilidad reconocida de las personas bilingües es su capacidad para seleccionar y producir palabras sólo en uno de los idiomas que conocen y cambiar de un idioma a otro cuando la situación lo requiere. Entonces, ¿cómo seleccionan el idioma adecuado cuando ambas lenguas están activas?, ¿qué mecanismo les permite controlar la producción del habla en L1 o en L2 evitando la influencia del uno sobre el otro? A continuación exponemos las perspectivas teóricas más relevantes sobre el procesamiento bilingüe que han intentando dar respuesta a estas cuestiones.

MECANISMOS DE SELECCIÓN DE IDIOMA

Desde las teorías sobre bilingüismo se han desarrollado diferentes perspectivas desde las que se intenta explicar cómo se lleva a cabo el control cognitivo en el procesamiento lingüístico de las personas bilingües y estas perspectivas difieren respecto a la forma en que se produce la activación y la posible competición entre los elementos de ambas lenguas. En nuestra opinión, estas perspectivas teóricas podrían agruparse en dos grupos según postulen o no procesos inhibitorios durante la selección de lenguas.

Mecanismos no-inhibitorios

Encontramos dos formas de explicar la selección de la lengua en que un bilingüe trabaja sin necesidad de inhibir la lengua irrelevante. En una de ellas se propone que, en realidad, no habría competición entre lenguas porque cuando un bilingüe se comunica en una de sus lenguas, solamente las representaciones de esa lengua entrarían en juego (Costa, 2005). Desde una segunda perspectiva se defiende la competición entre-lenguas y la resolución de la competición según el grado de activación de los competidores (Poulisse y Bongaerts, 1994).

Costa (2005; Costa, Miozzo y Caramazza, 1999) indica que sólo los ítems del idioma objetivo se tendrían en cuenta para la selección y posterior producción del habla, independientemente del nivel de activación de los ítems del idioma alternativo. Aunque elementos alternativos estén activos en ambas lenguas del bilingüe, no competirían entre sí porque la mera intención de hablar en uno de los idiomas es suficiente para que el mecanismo de selección se circunscriba a la lengua objetivo (ver Figura 1). Es decir, la activación no sería específica de idioma, la selección sí. Desde esta perspectiva, la competición entre ítems activados se produciría entre los ítems del idioma objetivo, no entre ítems de ambos idiomas. Además, aunque la interacción entre idiomas es posible, ésta sólo reflejaría el flujo de activación presente y no una verdadera competición para la selección.

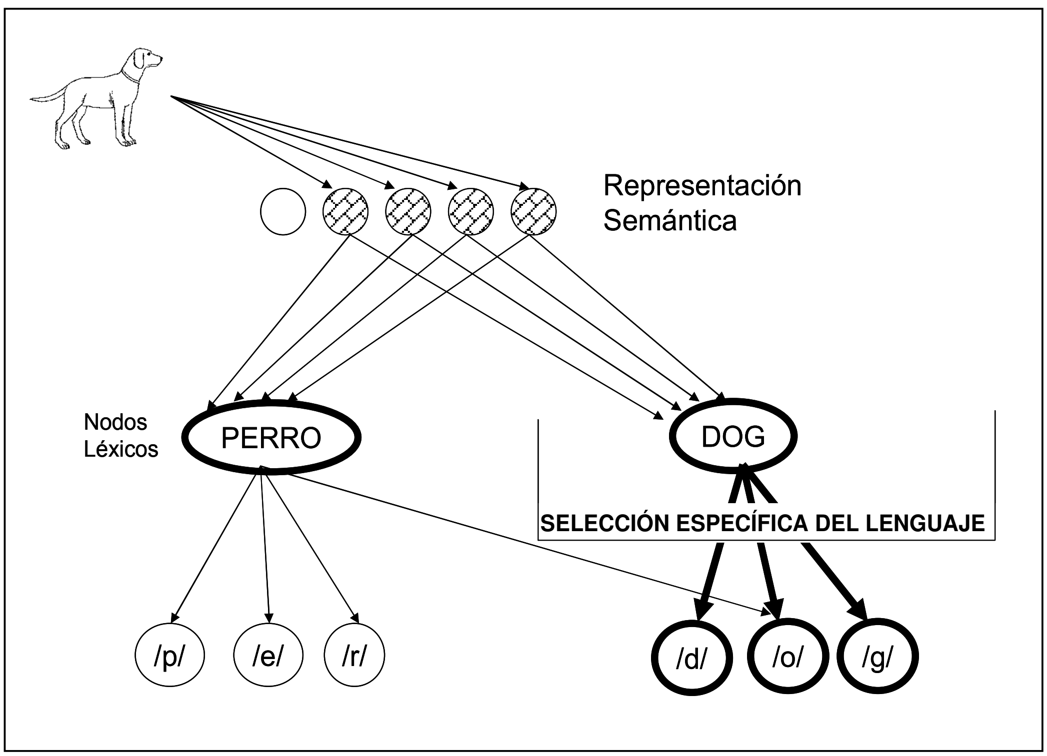

Figura 1. Modelo de acceso léxico bilingüe de Costa. Adaptado de Costa (2005).

Una prueba a favor de su modelo procede de un estudio en el que Costa et al. (1999) utilizaron una versión modificada del paradigma Stroop, en que se presentaba de forma simultánea estímulos relacionados por identidad. En personas monolingües se ha observado que la presentación previa o concurrente del nombre de un dibujo favorece su posterior denominación (Ferrand, Grainger y Segui, 1994). Este efecto de repetición se explica en base a la pre-activación que recibe el lemma del nombre del dibujo objetivo procedente del procesamiento de la palabra previa. En el estudio de Costa et al. (1999) un grupo de bilingües catalán/español tenían que nombrar dibujos en una de sus lenguas mientras que, simultáneamente, percibían una palabra sobre impuesta al dibujo. La palabra no estaba relacionada o era la traducción del nombre del dibujo (ensayos de identidad). Por ejemplo, en un ensayo de identidad, los participantes percibían el dibujo de un perro y lo nombraban en español mientras percibían concurrentemente la palabra *gos* (*perro* en catalán). En el caso de producirse competición léxica cabría esperar que los participantes mostrasen una peor ejecución en este tipo de ensayos: el tiempo empleado en decir *perro* sería mayor ya que un lemma competidor (*gos*) recibiría activación tanto de la presentación de la palabra escrita como de la procedente del dibujo. Sin embargo, los autores encontraron el patrón de resultados opuesto: la denominación de dibujos se realizó con mayor rapidez en los ensayos de identidad. Costa et al. (1999) explican el efecto de facilitación obtenido en los ensayos de identidad en base a la activación selectiva de idioma a partir de la intención del bilingüe. Es decir, si la persona desea hablar en español, sólo se computa la activación de los lemmas en español. En el caso de los ensayos de la condición de identidad, el nodo correcto *perro* recibiría doble activación, por un lado la que procede del dibujo y por otro lado la que procede de la traducción escrita *gos*. En cambio, en los ensayos de control, el lemma *perro* sólo se activaría tras la percepción del dibujo. Estos resultados apoyan la ausencia de competición entre dos lenguas aunque ambas estén activas de forma paralela.

Una segunda perspectiva defiende un mecanismo no selectivo de idioma, en el sentido de que todos los ítems son tenidos en cuenta para la selección independientemente del idioma al que pertenezcan. La selección del idioma objetivo se alcanzaría creando niveles de activación diferentes para L1 y L2. La cuestión que se plantea al respecto es cómo se produce este nivel diferencial de activación. Algunos autores proponen que la selección del idioma apropiado se produciría mediante el aumento en los niveles de activación de los ítems en la lengua objetivo respecto a los ítems de la lengua irrelevante (Poulisse y Bongaerts, 1994). Poulisse y Bongaerts (1994) proponen un modelo en el que una serie de marcadores de lenguaje actuarían a partir del nivel conceptual influyendo sobre los niveles de activación de las unidades léxicas de una de las lenguas. En concreto, proponen que todo el sistema léxico recibiría activación parcial procedente del sistema conceptual y, gracias a los marcadores de lenguaje, el subconjunto de lexemas de la lengua en uso recibiría más activación que los lexemas de la otra lengua (ver Figura 2).

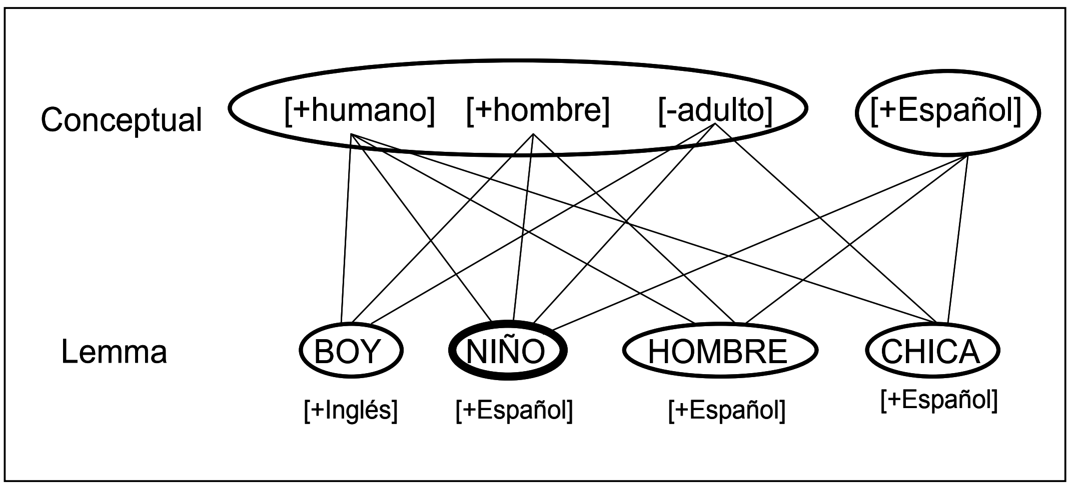

Figura 2. Procesos de selección bilingüe según Poulisse y Bongaerts. Traducido y adaptado de Poulisse y Bongaerts (1994, p. 41).

Por ejemplo, un bilingüe español/inglés cuando esté hablando en español activaría la representación léxica del lemma *niño* recuperando previamente en el nivel conceptual las características semánticas asociadas (humano, hombre y adulto) y el marcador de la lengua correcta (español). Las características semánticas enviarían activación a cualquier lemma de las dos lenguas que posea estos rasgos de significado. Por ejemplo, el rasgo "posee la característica de humano" [+humano] activaría a los lemmas *boy*, *niño*, *hombre* y *chica*, mientras que el rasgo "posee la característica de ser hombre" [+hombre] activaría a todos los lemmas anteriores excepto al nodo *chica*. En situaciones como la del ejemplo, habría dos nodos con igual potenciación (la palabra *niño* y su traducción al inglés *boy*) al recibir ambos activación de las mismas entradas semánticas. Sin embargo, finalmente se seleccionaría el lemma en la lengua correcta *niño*, por la activación procedente del marcador de lenguaje del nivel conceptual. El marcador de lengua [+Español] activaría a todos los lemmas de esta lengua y haría que, sumada su activación con la procedente de los rasgos semánticos, fuese *niño* el lemma más activo. Poulisse y Bongaerts (1994) defienden la existencia de un léxico unitario para las dos lenguas del bilingüe que funcionaría mediante la propagación de activación entre unidades. Por tanto, desde este modelo se postula que las representaciones léxicas de las dos lenguas estarían parcialmente activadas y competirían durante la producción bilingüe.

Así pues, mientras Costa (2005) defiende que la competición léxica en bilingües estaría restringida a los candidatos de la lengua en uso, Poulisse y Bongaerts (1994) mantienen que se produciría una competición entre candidatos de las dos lenguas. Sin embargo, desde ambas posturas se defiende un mecanismo de selección basado en la evaluación del grado de activación de los candidatos léxicos, similar a la ley de Luce (1959, aplicada a la mayoría de modelos de producción de habla monolingüe, v.g., el modelo WEAVER ++, Roelofs, 1997).

Procesos inhibitorios en la selección de lenguas

Respecto a la segunda postura, uno de los modelos más influyentes es el modelo de Control Inhibitorio (Inhibitory Control model, IC, Green, 1998). Este modelo intenta dar respuesta a la forma en que se produce el control en la selección de idioma en el procesamiento bilingüe teniendo en cuenta distintos niveles de procesamiento. Green (1998) propone que el control sobre la producción en el idioma objetivo se llevaría a cabo mediante la activación del idioma requerido y la inhibición de los ítems en el idioma alternativo que compiten por la selección. Más específicamente, este modelo propone que el procesamiento de idioma en bilingües implicaría distintos niveles de control. Un tipo de control se llevaría a cabo a partir de lo que Green denomina "esquemas de tarea de idioma" (*language task schemas*), que hacen referencia a una serie de secuencias de acción que permitirían a un bilingüe llevar a cabo una determinada tarea de idioma (nombrar palabras, traducir palabras, etc.). Un segundo tipo de control se llevaría a cabo a nivel léxico-semántico. Green propone que en el nivel léxico, los lemmas llevan asociados etiquetas lingüísticas (*language tag*) que tienen la función de especificar qué unidades pertenecen a cada una de las lenguas. Inicialmente se produce una activación indiscriminada de lemmas de las dos lenguas pero las etiquetas lingüísticas ejercen un control inhibitorio sobre los lemmas de la lengua que no está en uso. Estos dos tipos de control se llevarían a cabo de forma conjunta para permitir que un bilingüe lleve a cabo una determinada tarea en uno de sus idiomas.

Una asunción importante del modelo de Control Inhibitorio de Green (1998) es que la inhibición es reactiva y proporcional al nivel de activación de las palabras que han de ser inhibidas. El supuesto de reactividad del control inhibitorio se ha evaluado principalmente a partir de estudios que utilizan tareas de cambio de código (Meuter y Allport, 1999) en las que se toma la asimetría en el coste por cambio de tarea como índice de la inhibición. En el estudio de Meuter y Allport (1999), los participantes tenían que nombrar dígitos en su primera o segunda lengua en función del color de fondo de la pantalla que cambiaba de forma aleatoria. Los ensayos podían ser de dos tipos: ensayos de no cambio, en los que se requiere una respuesta en el mismo idioma que en el ensayo anterior, y ensayos de cambio, cuya respuesta ha de darse en el idioma alternativo en que se produjo la respuesta en el ensayo anterior. Los resultados mostraron la existencia de un coste en el tiempo de respuesta asociado al cambio de un idioma a otro. Es decir, los tiempos empleados para nombrar los dígitos fueron mayores en los ensayos de cambio respecto a los de no cambio. Además, se observó que el coste por cambio era mayor cuando se cambia de L2 a L1 que al contrario, lo que se conoce como efecto de asimetría. De acuerdo con la propuesta de Green, la tarea de nombrar en L2 (lengua no dominante) implicaría una fuerte inhibición reactiva hacia la representación en L1 (lengua dominante). Por tanto, al estar inhibida la representación en L1, se genera un alto coste al tener que cambiar y nombrar en la lengua anteriormente suprimida.

Aunque la mayor parte de los resultados en estos estudios apoyan el supuesto de reactividad de la inhibición y muestran el efecto de asimetría, un problema a esta cuestión se deriva de la propia utilización de las tareas de cambio de código ya que con este procedimiento no se obtiene una medida directa de la inhibición, sino que ésta se infiere a partir del efecto de asimetría observado. De manera adicional, en los estudios sobre la asimetría por cambio de lengua la persona bilingüe se somete a una situación de interferencia artificialmente alta, dado el cambio constante de una lengua a otra. Por tanto, cabría preguntarse si los procesos de inhibición entre lenguas actúan en situaciones más naturales en las que el bilingüe tiene que trabajar solamente en una de sus lenguas durante toda la tarea experimental.

Otro de los modelos que intenta dar respuesta a la forma en que se produce el control de idioma en base a los efectos de acceso léxico no selectivo en bilingües es el modelo BIA (Bilingual Interactive Activation model, Dijkstra y Van Heuven, 1998). De acuerdo con el modelo BIA, el control en la selección de idioma se llevaría a cabo mediante un proceso interactivo de activación e inhibición. Este modelo asume cuatro niveles de representaciones lingüísticas: nivel de características de letras; nivel de letras; nivel de palabras; y nivel de nodos de idioma. De acuerdo con este modelo, a partir de la identificación de las características de letras y de las letras, se activarían distintas entradas léxicas en ambos idiomas del bilingüe, ya que el modelo asume la existencia de un léxico integrado incluyendo palabras de ambos idiomas, y por tanto la activación no selectiva de L1 y L2. A su vez, estas entradas léxicas activarían el nodo de idioma al que están conectadas en distinto grado dependiendo del contexto de idioma. Las entradas léxicas activas competirían entre sí por la selección, que se llevaría a cabo mediante el control de la activación a partir de dos mecanismos diferentes. Por un lado, las entradas léxicas pueden inhibir a otras de su mismo idioma mediante lo que los autores denominan *inhibición lateral*. Por otro lado, los nodos de idioma pueden inhibir la activación de las entradas léxicas del otro idioma. El resultado de estos procesos de activación e inhibición llevaría a la selección de la entrada léxica con mayor nivel de activación.

En este primer apartado hemos revisado parte de la literatura en relación a algunos de los aspectos más relevantes sobre el procesamiento de idiomas en bilingües. Como hemos visto, la activación simultánea de ambas lenguas es un fenómeno demostrado que conlleva procesos de interacción y mutua influencia entre las mismas. Algunos de los efectos derivados de la activación no selectiva de los idiomas en personas bilingües han llevado a plantear cuáles son los mecanismos que permiten la selección del idioma relevante en una circunstancia dada. Así, hemos revisado distintas perspectivas teóricas sobre el procesamiento bilingüe que han intentando dar respuesta a esta cuestión. Aunque estas perspectivas difieren en el tipo de mecanismo implicado en la selección de idioma (mecanismos de naturaleza inhibitoria vs. mecanismos no inhibitorios), actualmente gran parte de la evidencia aportada por distintos estudios sugiere que los procesos de selección de idioma son de naturaleza inhibitoria (Kroll, Bobb, Misra y Guo, 2008; Macizo, Bajo y Martín, 2010). Si a partir de la activación no selectiva de ambas lenguas se producen procesos de competición entre las representaciones activas, desde una perspectiva inhibitoria sería necesaria la participación de mecanismos de control de naturaleza inhibitoria para seleccionar la representación relevante. Si bien la inhibición es un proceso necesario para resolver la competición entre lenguas, puede conllevar un coste de tiempo asociado cuando la representación inhibida ha de activarse posteriormente. Si un bilingüe cuando está haciendo uso de una de sus lenguas requiere de la inhibición de ciertas representaciones, cabe preguntarse cuánto tiempo necesita para sobreponerse a las consecuencias de este efecto inhibitorio. A continuación profundizaremos en uno de los aspectos relacionados con la naturaleza de los procesos de control en la selección de idioma: el curso temporal de la inhibición.

PARÁMETROS TEMPORALES DE LOS PROCESOS DE CONTROL INHIBITORIO EN LA SELECCIÓN DE IDIOMA

Aunque los resultados de numerosos estudios sugieren la participación de procesos de control de tipo inhibitorio en la selección de idioma en bilingües, aún permanece abierta la cuestión acerca del curso temporal de la inhibición. A continuación expondremos los resultados de algunos trabajos previos que han motivado nuestro interés por estudiar de forma directa esta cuestión.

Como se ha expuesto anteriormente, la participación de los procesos inhibitorios en los procesos de activación y selección de idiomas en bilingües se ha abordado mediante el uso de homógrafos entre lenguas. Si se produce la activación simultánea de dos lenguas, la presencia de un homógrafo llevará a una situación de interferencia por la competición que se produce entre los dos significados alternativos del homógrafo. Desde una perspectiva inhibitoria, para seleccionar el significado objetivo, el significado irrelevante habría de ser inhibido. Sin embargo, existe un debate abierto en diversos estudios monolingües y de procesamiento bilingüe acerca del curso temporal de la activación del significado irrelevante del homógrafo (Altarriba y Gianico, 2003; Balota y Paul, 1996; Beauvillain y Grainger, 1987; Chwilla y Kolk, 2003).

Beauvillain y Grainger (1987) realizaron un estudio sobre el procesamiento de homógrafos entre lenguas utilizando un paradigma de priming. Los participantes eran bilingües de inglés/francés y tenían que leer palabras en francés entre las que se incluían homógrafos, como por ejemplo “coin” (que significa moneda en inglés y esquina en francés). A continuación realizaban una tarea de decisión léxica sobre palabras en inglés que podían estar relacionadas o no con el significado en inglés de los homógrafos. Los resultados mostraron un efecto de facilitación para las palabras en inglés relacionadas con el significado irrelevante de los homógrafos presentados en primer lugar (“coin-money”), lo que indica la activación de los significados del homógrafo en ambos idiomas. No obstante, este efecto de priming semántico sólo aparecía cuando las palabras en inglés se presentaban con un SOA (*stimulus onset asynchrony*) de 150 ms.

después de la aparición de las palabras en francés, desapareciendo cuando el SOA alcanzaba los 750 ms. Estos resultados sugieren que la activación de los dos significados del homógrafo podría estar presente en las primeras etapas del procesamiento y desaparecería posteriormente. Pero aún no se ha podido explicar por qué el significado irrelevante del homógrafo estaría menos activado ante un SOA más largo. Uno de los problemas del estudio de Beauvillain y Grainger consiste precisamente en la dificultad para establecer una condición de línea base que permita demostrar que la ausencia del efecto con SOAs largos se debe a la inhibición del significado irrelevante del homógrafo y no a otras causas como el mero decaimiento de la activación por el paso del tiempo. En estudios monolingües sobre el procesamiento de homógrafos sí se ha utilizado una condición control de este tipo. Por ejemplo, Gernsbacher y Faust (1990) incluyeron en su estudio una condición control en la que se proporcionaba un contexto a partir de frases neutrales para cada uno de los significados de las palabras ambiguas. Los autores encontraron que ante el contexto neutral los dos significados de las palabras ambiguas se activaban tanto en los SOAs cortos como en los largos. Este resultado indica que, en ausencia de un contexto que induzca a un sesgo en la respuesta, los dos significados de la palabra ambigua se mantienen activos y que esta activación no decae con el paso del tiempo. En el estudio de Beauvillain y Grainger, sin embargo, el contexto que induce al sesgo es el propio idioma en el que se presentan las palabras ambiguas, haciendo imposible la introducción de una condición control que no induzca al sesgo o bien hacia el significado en francés o bien hacia el significado en inglés del homógrafo.

Un aspecto importante a tener en cuenta tiene relación con el tipo de paradigma utilizado en el estudio de los procesos inhibitorios en la selección de idioma, ya que la duración de los efectos encontrados depende en muchos casos del paradigma empleado. Por ejemplo, los paradigmas de priming negativo (Tipper y Driver, 1988) y de práctica en la recuperación (Anderson, Bjork y Bjork, 1994) que tradicionalmente se han utilizado para el estudio de los procesos inhibitorios en memoria y atención, han sido utilizados recientemente para el estudio de los procesos inhibitorios en el procesamiento lingüístico en bilingües (Levy, McVeigh, Marful y Anderson, 2007; Macizo et al., 2010). Ambos paradigmas difieren, entre otros muchos aspectos, en los efectos temporales de la inhibición. En el paradigma de priming negativo, los efectos de la inhibición son observados en intervalos de milisegundos, mientras que en el paradigma de práctica en la recuperación, se han hallado efectos inhibitorios más duraderos (Levy et al., 2007). En su estudio, Levy et al. presentaban a bilingües de ingles-español (L1: inglés; L2: español) dibujos que tenían que ser nombrados de forma repetida en su segunda lengua (español, v.g., *serpiente*). A continuación, los participantes tenían que recuperar los nombres en inglés de los dibujos presentados con ayuda de una clave de rima (se presentaba una palabra a los participantes y estos tenían que decir una palabra en inglés que rimase con alguno de los dibujos que se habían presentado previamente, v.g., *break_*). Los resultados mostraron que el recuerdo de las palabras en L1 era menor tras nombrar repetidamente dibujos en L2. Este efecto (olvido inducido por la recuperación, OIR) se explica asumiendo que los nombres de los dibujos en L1 compiten por la selección cuando los participantes tienen que nombrar dibujos en su L2, y esto tiene como consecuencia la inhibición de la representación fonológica de las palabras en L1. De esta forma, ante la clave de rima presentada en la fase de recuerdo final, los participantes mostraron mayor dificultad para recuperar la representación fonológica de las palabras en L1. Una característica a resaltar de este efecto inhibitorio es que pudo observarse en un intervalo posterior al momento en que se produjo la competición entre las representaciones en L1 y L2. En el estudio de Levy et al., la competición ocurría en la fase de nombrado de dibujos, mientras que la inhibición se observó en una fase de test posterior (alrededor de 20 minutos después).

Puede que las diferencias metodológicas entre los dos tipos de paradigma expliquen las diferencias encontradas en cuanto a la duración del efecto de la inhibición. Es posible que el hecho de inhibir de forma repetida la misma representación haga que los efectos de la inhibición sean más duraderos. Mientras que en un caso la inhibición parece tener un efecto efímero, en el otro parece perdurar por un periodo de tiempo más largo. En el presente trabajo pretendemos explorar más profundamente esta cuestión.

ÍNDICES ELECTROFISIOLÓGICOS DE LOS PROCESOS DE ACTIVACIÓN Y CONTROL INHIBITORIO EN LA SELECCIÓN DE IDIOMA

La mayor parte del conocimiento sobre el procesamiento de idiomas en bilingües se ha basado en los resultados obtenidos a partir de medidas conductuales (Dijkstra, 2005). No obstante, recientemente hemos observado un creciente interés por la utilización de técnicas que permiten obtener medidas fisiológicas del procesamiento bilingüe en tiempo real. Por ejemplo, la utilización de potenciales cerebrales relacionados con eventos (ERPs) permite obtener una medida de la actividad cerebral relacionada con un evento a nivel de milisegundos, lo que nos aporta información sobre el curso temporal de distintos subprocesos lingüísticos implicados en el procesamiento de una determinada lengua.

Uno de los componentes cerebrales que se ha relacionado con distintos aspectos del procesamiento lingüístico ha sido el componente N400. El componente N400 es un potencial de voltaje negativo cuyo pico de amplitud aparece alrededor de los 400 milisegundos tras la aparición del estímulo, principalmente en localizaciones parietales, temporales posteriores y occipitales del hemisferio derecho. La evidencia empírica ha mostrado que este componente es especialmente sensible al procesamiento semántico (Kutas, Van Petten, y Kluender, 2006). Así, se han observado diferencias en la amplitud en el N400 en relación a distintos aspectos del procesamiento semántico como por ejemplo, la relación semántica entre palabras (mayor amplitud en el N400 cuando una palabra es precedida por otra no relacionada que cuando es precedida por una palabra que sí lo está), o el efecto del contexto en los procesos de integración (mayor amplitud en el N400 cuando una palabra es incongruente con el contexto de la frase en la que se encuentra), entre otros. El efecto en el N400 se ha encontrado en distintas modalidades sensoriales, en distintos idiomas y a través de un amplio rango de tareas (ver Kutas et al., 2006, para una revisión).

Los resultados obtenidos a lo largo de una serie de estudios apuntan a que la amplitud del componente N400 puede considerarse como un índice general de la facilidad o dificultad con que se recupera el conocimiento conceptual almacenado asociado a una palabra, y que puede depender tanto de la representación almacenada en la memoria per se, como de las claves de recuperación proporcionadas por el contexto (Kutas et al., 2006). Por otro lado, en contextos monolingües se ha encontrado que las palabras con mayor número de vecinos ortográficos (palabras que pueden formarse cambiando una letra) provocan mayores amplitudes en el N400 que las palabras con menor número de ellos, aunque ante las primeras se observan tiempos de respuesta en decisión léxica más rápidos (Holcomb, Grainger y O'Rourke, 2002). Este efecto se ha explicado en base a una mayor activación semántica global cuando se selecciona una palabra que posee gran número de vecinos ortográficos debido a la presencia de activación parcial correspondiente a palabras cercanas ortográficamente. Esta activación debe ser suprimida para poder acceder correctamente al significado de la palabra seleccionada.

Otro de los componentes de interés en el estudio del procesamiento bilingüe es el N200, ya que la influencia de la L1 sobre el procesamiento de la L2 puede verse reflejada en este componente. Este componente se ha estudiado en relación a distintos aspectos como la inhibición de respuestas (Rodriguez-Fornells, Schmitt, Kutas y Münte, 2002), la negatividad por disparidad fonológica (Van den Brink, Brown y Hagoort, 2001) o en relación a aspectos relacionados con el procesamiento de la forma ortográfica de la palabra (Bentin, Mouchetant-Rostaing, Girad, Echallier y Pernier, 1999). Pero en relación al procesamiento bilingüe, este componente se ha relacionado principalmente con procesos de control inhibitorio en la selección de idiomas.

Los estudios que han utilizado ERPs para explorar el control cognitivo en el procesamiento bilingüe se han centrado fundamentalmente en el efecto de la inhibición de respuestas sobre el N200. Este efecto se ha observado normalmente a partir de la utilización del paradigma *go/no-go*, en el que los participantes tienen que responder ante determinados estímulos (go) y contener la respuesta ante otro tipo de estímulos (no-go). En estas condiciones se observa un potencial más negativo en áreas frontales que aparece alrededor de los 200 ms ante las respuestas *no-go* respecto a las respuestas *go* (ver Moreno, Rodriguez-Fornells y Laine, 2008; Rodriguez-Fornells, De Diego Balaguer y Münte, 2006, para una revisión). Este tipo de paradigma también se ha utilizado para el estudio de aspectos relacionados con la recuperación de información conceptual, sintáctica y fonológica tanto en producción como en comprensión (ver Jansma, Rodriguez-Fornells, Möller y Münte, 2004, para una revisión).

Aunque los ERPs se han utilizado principalmente en la investigación de los procesos lingüísticos en la primera lengua, recientemente se han utilizado para explorar el procesamiento en la segunda lengua. En este sentido, varios estudios han utilizado medidas electrofisiológicas para el estudio de la activación léxica no selectiva y la participación de los procesos inhibitorios en la selección de idioma en bilingües. Como hemos visto anteriormente, una estrategia ampliamente utilizada para estudiar estos procesos ha consistido en el uso de estímulos que comparten características lingüísticas en ambas lenguas de la persona bilingüe, como es el caso de los homógrafos entre lenguas (Beauvillain y Grainger, 1987; De Bruijn, Dijkstra, Chwilla y Schriefers, 2001; Elston-Güttler, Paulmann y Kotz, 2005; Kerkhofs, Dijkstra y Chwilla, 2006; Macizo et al., 2010; Moreno et al., 2008).

Algunos estudios previos sobre el procesamiento de homógrafos en bilingües han utilizado un procedimiento de priming semántico tomando como medidas el tiempo de reacción y ERPs (De Bruijn et al., 2001; Kerkhofs et al., 2006). Kerkhofs et al. en su estudio utilizaron un paradigma de priming semántico similar al usado por Beauvillain y Grainger (1987) para estudiar los efectos del contexto semántico y léxico sobre los tiempos de reacción y ERPs en bilingües de alemán/inglés. Los participantes realizaban una tarea de decisión léxica en un único contexto de idioma (su L2, inglés) con homógrafos alemán/inglés. Las palabras objetivo podían ser homógrafos alemán/inglés, palabras en inglés (control) o no palabras, e iban precedidas por palabras exclusivamente en inglés que podían estar semánticamente relacionadas o no con las anteriores. Los autores observaron tiempos de respuesta más rápidos para los homógrafos que eran precedidos por palabras relacionadas que para los homógrafos precedidos por palabras no relacionadas. En cuanto a los ERPs, se observaron amplitudes menores en el N400 en las condiciones precedidas por palabras relacionadas que en las precedidas por palabras no relacionadas. Los autores consideraron que el patrón de resultados obtenido tanto en los tiempos de reacción como en los ERPs apoya la perspectiva de acceso léxico no selectivo y refleja la presencia de procesos de integración semántica.

En el presente trabajo de investigación trataremos de obtener evidencia sobre los correlatos neurales de la interferencia producida por la activación no selectiva de ambas lenguas y de la presencia de procesos de control en la selección de idioma.

FACTORES MODULADORES DE LOS PROCESOS DE ACTIVACIÓN CONTROL INHIBITORIO EN LA SELECCIÓN DE IDIOMA

La investigación realizada en el ámbito del bilingüismo ha intentado dar respuesta a cómo están representados los idiomas en la mente de la persona bilingüe y cómo los bilingües pueden seleccionar el idioma que necesitan en una circunstancia dada (ver Kroll y Tokowicz, 2005, para una revisión). Aunque son numerosos los estudios que han mostrado la activación simultánea de ambos idiomas de un bilingüe, incluso en aquellas situaciones en las que sólo uno de ellos es necesario, la activación no selectiva de ambos idiomas no siempre se ha observado e investigaciones previas sugieren que ésta puede depender de diversos factores (Christoffels, De Groot y Kroll, 2006; Ibáñez et al., 2010; Linck et al., 2009). Por otro lado, la activación no selectiva de ambos idiomas facilita la oportunidad para que ambos idiomas interactúen entre sí, pudiendo llevar a una situación de competición entre representaciones de ambas lenguas cuando el bilingüe ha de seleccionar la representación adecuada en sólo una de ellas. En este sentido, la evidencia empírica sugiere que el grado de competición entre ambos idiomas puede estar influenciado por factores tales como el nivel de competencia y dominancia de cada una de las lenguas (Costa y Santesteban, 2004; Elston-Güttler et al., 2005), los recursos cognitivos de la persona bilingüe (Ibáñez et al., 2010; Macizo y Bajo, 2006), el contexto en que se encuentre inmerso el bilingüe (Link et al., 2009) o la experiencia particular en el uso de las lenguas (ver Kroll et al., 2006, para una revisión).

A continuación revisaremos la evidencia empírica en relación a dos de los factores que resultan de interés para el presente trabajo: la inmersión en un contexto de L2 y la experiencia en traducción.

Inmersión en un contexto de segunda lengua

La competición entre lenguas se ha observado con mayor facilidad en bilingües que están expuestos de forma continuada a su lengua nativa (L1) y son evaluados en su segunda lengua (L2). En estas circunstancias, es razonable esperar que se produzca competición de la lengua irrelevante (en este caso, la L1) por el hecho de que ésta es la lengua dominante y el entorno (i.e., contexto de uso de L1) va a favorecer su activación.

La literatura existente en relación al procesamiento bilingüe ha aportado numerosa evidencia de la activación de la L1 en bilingües inmersos en un contexto de L1 cuando éstos son evaluados en su L2, tanto en tareas de producción (Kroll et al., 2006; Marian y Spivey, 2003) como en tareas de comprensión (Dijkstra, 2005; Dijkstra y Van Heuven, 2002; Macizo et al., 2010).

Sin embargo, un contexto de inmersión en L2 se caracteriza principalmente por que en dicho entorno predomina la exposición a la segunda lengua del bilingüe, tanto auditiva como visualmente. En una situación así, la influencia de la primera lengua del bilingüe podría verse reducida cuando éste realiza una tarea lingüística en su segunda lengua, y así el contexto de inmersión en L2 podría reducir el grado de competición entre idiomas.

Aunque hasta el momento no existen muchos estudios sobre el efecto de la inmersión en L2 sobre el procesamiento bilingüe, los resultados de estudios existentes sobre este factor sugieren que un contexto de inmersión en L2 puede llevar a un cambio en la forma en que son procesadas ambas lenguas del bilingüe. En su estudio, Link et al. (2009) compararon la ejecución de dos grupos de hablantes nativos de inglés que aprendían una segunda lengua (español) en dos contextos de aprendizaje diferentes. Uno de los grupos estudiaba español en un contexto de aprendizaje en clase (contexto de clase), mientras que el otro estudiaba español en el extranjero durante un periodo de seis meses (contexto de inmersión). Los participantes realizaban una tarea de reconocimiento de la traducción y una tarea de fluidez verbal, tanto en L1 como en L2. En la tarea de reconocimiento de la traducción se presentaban pares de palabras de forma que cada una de las palabras del par se presentaba en cada uno de los idiomas de los participantes (una palabra en L2 y la otra en L1, v.g., *cara-face*). La tarea de los participantes consistía en decidir si las palabras del par presentado eran traducciones equivalentes. La manipulación crítica consistía en que las palabras dentro de un par podían tener parecido en la forma léxica con la palabra en español (v.g., *cara-card*), con la traducción al inglés (v.g., *cara-fact*), o podían estar relacionadas con el significado de la palabra en español (v.g., *cara-head*). El grupo de estudiantes en contexto de clase mostró un efecto de interferencia en las tres condiciones experimentales, mientras que el grupo de estudiantes en contexto de inmersión en L2 no mostró interferencia en la condición de parecido en la forma léxica de las palabras. Además, los resultados obtenidos en la tarea de fluidez verbal mostraron que el grupo de estudiantes en contexto de inmersión en L2 generó un mayor número de palabras en español y, particularmente, generó un menor número de palabras en su L1, el inglés. El patrón de resultados observado, tanto en comprensión como en producción, sugiere la activación de la L1 y el grado de competición de la L1 sobre la L2 fueron significativamente menores en el grupo de estudiantes en contexto de inmersión.

Experiencia en traducción

El papel de la experiencia en traducción ha sido previamente explorado en relación a aspectos lingüísticos y los procesos cognitivos implicados en tareas de traducción e interpretación (Christoffels y De Groot, 2005; Christoffels et al., 2006;

Ibáñez et al., 2010; Macizo y Bajo, 2006).

Cuando un traductor se enfrenta a la tarea de traducir, su tarea consiste básicamente en comprender un mensaje expresado en una lengua y reformularlo en otra lengua. Dejando a un lado las diferencias existentes entre las diversas modalidades de traducción, la característica principal de la tarea de traducción consiste en que el traductor no sólo tiene que comprender y reformular un mensaje de una lengua a otra diferente, sino que también tiene que mantener las dos lenguas activas y cambiar de una a otra continuamente. De esta forma, un traductor tiene que manejar la activación de las dos lenguas y enfrentarse continuamente la interferencia producida por la activación paralela de ambas lenguas durante la tarea de traducción.

Aunque existe numerosa evidencia que sugiere la implicación de procesos de control inhibitorio en la selección de idioma en bilingües (v.g., Green, 1998), este tipo de mecanismo no parece ser el más apropiado para realizar tareas de traducción, ya que en este tipo de tarea una de las lenguas ha de estar activa para poder comprender el mensaje de entrada mientras que la otra tiene que estar igualmente activa para poder producir el mensaje de salida de forma simultánea.

A pesar de la escasa investigación realizada sobre la experiencia en traducción como factor modulador de la forma en que los bilingües regulan la activación de sus lenguas, los resultados obtenidos por Ibáñez et al. (2010) sugieren que los bilingües podrían diferir en la forma en que manejan sus dos o más lenguas. En el trabajo realizado por Ibáñez et al., traductores profesionales y bilingües sin experiencia en traducción realizaban una tarea que consistía en leer y comprender frases, y repetirlas en el idioma en que se presentaban que podía ser español (L1) o inglés (L2). Con el objetivo de explorar la activación no selectiva de ambas lenguas, los autores incluyeron palabras cognadas (v.g., zebra/cebra, en español e inglés, respectivamente) como estímulos críticos dentro de las frases. De esta forma, un posible efecto de cognado se consideraría como un índice de la activación no selectiva de ambas lenguas. Por otro lado, y con el objetivo de explorar la naturaleza del mecanismo de selección de idioma, los autores realizaron una adaptación del paradigma de cambio de idioma (v.g., Meuter y Allport, 1999) a la tarea de lectura de frases, de manera que las frases podían presentarse en español (L1) o en inglés (L2) de una forma impredecible. En este caso, los autores tomaron el efecto de asimetría en el cambio de idioma (mayor coste asociado al cambio de la lengua menos dominante, L2, hacia la lengua dominante, L1, que al contrario) como un índice de control inhibitorio. Los resultados indicaron que los traductores mostraron el efecto de cognado pero, a diferencia del grupo de bilingües, no mostraron el efecto de asimetría por el cambio de idioma. Este patrón de resultados sugiere que los traductores mantendrían activas sus dos lenguas pero no ejercerían control inhibitorio sobre ninguna de ellas. Dado que ambos grupos de participantes no diferían entre sí, salvo en su experiencia en traducción, las diferencias observadas entre ambos grupos no serían atribuibles a diferencias en el nivel de conocimiento de la L2, sino al factor de la experiencia en traducción.

ORGANIZACIÓN Y OBJETIVOS DE LA SERIE EXPERIMENTAL

La serie experimental incluida en el presente trabajo de investigación tiene como principal objetivo profundizar en el acceso léxico no selectivo y en los procesos de control en la selección de idioma en bilingües de español-inglés (L1: español; L2: inglés). Para ello utilizamos una tarea de juicio de relación semántica (una adaptación de la tarea de priming negativo) entre pares de palabras presentadas en la L2 de los participantes incluyendo como estímulos críticos homógrafos entre lenguas. Al ser la tarea utilizada una adaptación de la tarea de priming negativo, nos va a permitir tomar dos tipos de índices o medidas. Por un lado, el efecto interferencia en respuesta a los pares de palabras con homógrafos entre lenguas será considerado como un índice de la activación no selectiva de ambos significados del homógrafo. Y por otro lado, la demora en la respuesta ante los pares de palabras que requieran la reactivación del significado irrelevante del homógrafo presentado previamente, será considerada como un índice de la actuación de mecanismos inhibitorios para resolver la competición creada entre ambas representaciones. Utilizaremos esta tarea a lo largo de toda la serie experimental.

La serie experimental se desarrolla en los Capítulos III, IV, V y VI, cada uno de los cuales responde a los objetivos específicos que nos planteamos en la presente tesis. Esta serie experimental está estructurada de la siguiente forma.

En el Capítulo III investigamos la activación de idioma y la implicación de procesos de naturaleza inhibitoria en la selección de idioma a través del procesamiento de homógrafos entre lenguas en bilingües de español-inglés. Si la activación paralela de ambas lenguas tiene lugar, la presencia de un homógrafo producirá interferencia por la activación de ambos significados del homógrafo, haciendo necesaria la participación de procesos inhibitorios para seleccionar el significado relevante. Este capítulo incluye dos experimentos. El Experimento 1 pretende aportar evidencia de la presencia de procesos inhibitorios en la selección del significado correcto de un homógrafo español-inglés utilizando pares de palabras. El Experimento 2 tiene como objetivo explorar la presencia de los procesos inhibitorios cuando las palabras se presentan de forma aislada. En este experimento se incluyen los estímulos utilizados en el experimento previo, pero adaptados en este caso a una tarea de decisión léxica en inglés.

En el Capítulo IV pretendemos obtener nueva evidencia de los procesos de interés observados en el Capítulo II utilizando una técnica de alta resolución temporal como es el registro de los ERPs. En el experimento incluido en este capítulo se tomaron tanto medidas electrofisiológicas como conductuales, adaptando la tarea de decisión semántica utilizada previamente al registro del electroencefalograma.

El Capítulo V pretende explorar los parámetros temporales de los procesos inhibitorios en la selección de idioma. En este capítulo incluimos dos experimentos que difieren en el intervalo temporal que transcurre desde el momento en que se observa la interferencia en la tarea de decisión semántica hasta el momento en que se hace necesaria la actuación de los procesos inhibitorios para resolver la competición entre representaciones.

La serie experimental incluida en el presente trabajo de investigación se cierra con el estudio incluido en el Capítulo VI. En este capítulo examinamos el efecto de la inmersión en L2 y la experiencia en traducción sobre los procesos de activación léxica y los procesos de control en la selección de idioma. Con este objetivo evaluamos los procesos de interés en tres grupos de bilingües de español-inglés, que difieren en el contexto de inmersión (i.e., contexto de L1 o L2) y en su experiencia en tareas de traducción.

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CHAPTER II

SUMMARY INTRODUCTION, AIMS AND STRUCTURE OF THE THESIS

The fact that cross-language activation is observed even when bilinguals are required to only use one of their languages raises the question about how they select the language they need according to the context. Much of the bilingual language processing research has focused on understanding the control mechanisms that allows them to overcome the negative influence of activating their two languages. In the current thesis we will focus on how bilinguals access to the required lexical representations when language co-activation occurs, and on the control mechanisms involved in language selection.

The main goal of the current dissertation is to focus on the cognitive control processes involved in solving between-language competition. In addition, along the empirical studies included in the thesis we develop specific objectives regarding the inhibitory control mechanisms involved in language selection: (1) to explore the cortical activity associated to the cross-language activation and to the inhibitory processes recruited to solve the competition between representations; (2) to investigate some features of these processes such as the time course of inhibition; and (3) to investigate the influence of immersion in a second language environment and expertise in translation on cross-language activation and language selection processes.

The first part of the thesis includes an introduction chapter (Chapter I, in Spanish) and the current chapter (Chapter II) in which we summarize the main contents included in Chapter I and briefly outlines the main goals and the organization of the studies included in this thesis. In Chapter I, we developed different sections containing a general theoretical review concerning each of the aims of the present dissertation. First, we reviewed the main theoretical perspectives on bilingual language processing that have attempted to answer how lexical access is achieved in bilinguals and which are the control mechanisms involved in language selection. Second, we reviewed the main electrophysiological components related to cross-language activation and language selection in bilinguals. Third, we raised the main empirical studies that have motivated the experiments regarding the time course of inhibitory processes in language selection. Finally, we focused on previous studies in relation to modulating factors of bilingual language processing (i.e., immersion in a second language context and expertise in translation). In the following sections we summarize the contents in Chapter I outlined above.

LEXICAL ACCESS IN BILINGUALS

Recent research on bilingualism has tried to answer how languages are represented in the bilingual mind and how bilinguals select the language they need (see Kroll & Tokowicz, 2005; for a review). Many studies have shown that the two languages of the bilingual are active even when the bilinguals need to use only one (non-selective activation, see Dijkstra, 2005; for a review). Two important remarks are relevant for the present work: first, given that language co-activation occurs, the presence of between-language competition introduces the need for a control mechanism that regulates the activation of the non-target language in order to correctly select the intended one; second, the non-selective activation of the two languages may rise differences on lexical access and the degree of between-language competition depending on several factors such as language proficiency and dominance (Costa & Santesteban, 2004; Elston-Güttler, Paulmann, & Kotz, 2005), the cognitive resources available to the bilingual (Ibáñez, Macizo, & Bajo, 2010; Macizo & Bajo, 2006), the context in which the bilinguals are immersed or their particular experience with the language (see Kroll, Bobb, & Wodniecka, 2006; for a review).

Most of the studies on cross-language interactions in bilinguals have use the general strategy of using words that share lexical, orthographic or phonological properties in two languages (e.g., false friends or homographs, cognates and homophones). For instance, some studies using naming or lexical decision tasks have shown that cognates (i.e., words with the same meaning and total or partial orthographic and phonological overlap in two languages; for example, *cebra*, in Spanish, and *zebra*, in English) are processed faster than control words (i.e., *cognate effect*; Costa, Caramazza, & Sebastián-Gallés, 2000; Dijkstra, Grainger, & Van Heuven, 1999; Lemhöfer & Dijkstra, 2004).

In addition, in bilingual research interlexical homographs have been also used to study cross-language activation in bilinguals (Beauvillain & Grainger, 1987; De Groot, Delmaar, & Lupker, 2000). Interlingual homographs are words with the same written form but different meaning in the two languages of the bilingual. For example, a word such as "*pie*" means *cake* in English, but it means *foot* in Spanish. If the two languages are activated during the processing of a given word by the bilinguals, all the homograph meanings will be activated regardless of the specific language context in which the homograph was presented.

While the cognate effect has been observed by using different tasks, cross-language interactions observed through the use of homographs have yield mixed results. So, non-selective activation of the two meanings may either benefit or hinder the participants' performance depending on the task and the stimuli characteristics (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Schwartz & Kroll, 2006; Von Studnitz & Green, 2002). For example, Dijkstra, Van Jaarsveld, and Ten Brinke (1998; Experiment 3) asked Dutch/English bilinguals to decide whether or not a letter string was a word in English or Dutch. The material consisted of Dutch words, English words, Dutch/English interlingual homographs and non-words. The results showed that homographs were responded to more rapidly than non-homograph control words indicating that the activation of the two homograph meanings caused an improvement in the participants' performance because the task required recognizing words irrespective of the language in which they were presented. In contrast, other studies have shown that the activation of the two meanings of an interlingual homograph may hinder the bilinguals' performance when just one of the meanings is required to perform the task. De Groot et al. (2000) asked Dutch/English bilinguals to decide whether pairs of words (a Dutch word and an English word) were translation equivalents. When pairs contained an interlingual homograph (e.g., "*glad*", meaning *slippery* in Dutch), participants slowed their response times as compared to matched controls. This was so because the non-target meaning activation (*slippery*) competed with the target meaning of the homograph (the English meaning of "*glad*": *pleased*).

The results described above suggest that the non-selective language activation may lead to between-language competition processes, and so, L2 processing might be affected by the interference aroused between the bilingual's two languages. However, a well-known bilinguals' skill is their ability to select the appropriate language and to switch between languages according to the context. Then, how do they select the right language when both languages are active? Which is the control mechanism that allows overcoming the negative influence between L1 and L2 interactions? In order to provide an answer to this question, several approaches have been developed from bilingualism research.

LANGUAGE SELECTION MECHANISMS

Different perspectives have been developed from bilingual theories that have attempted to explain how language control is achieved in bilingual processing. These perspectives propose different explanations about how cross-language activation and between-language competition processes are produced, and regarding the control mechanisms involved in language selection (non-inhibitory vs. inhibitory mechanisms).

Non-inhibitory perspectives

We will refer two main proposals that have aimed to explain how bilinguals select the target language without inhibiting the irrelevant one. One proposal upholds that only one language would be consider for selection and so there would be not between-languages competition (Costa, 2005). A second proposal upholds the presence of between-languages competition and that this competition would be solved depending on activation level of the competitors (Poulisse & Bongaerts, 1994).

Costa (2005; Costa, Miozzo, & Caramazza, 1999) proposes that only the target language items would be considered for selection and language production, independently of the activation level of the non target items. Although items in both languages are active, this parallel activation would not produce competition since the mere intention to speak in one language is enough to select the target language. In other words, from this perspective the lexical selection mechanism would be language specific and only activated items in the target language would be considered for selection. Evidence supporting this model comes from a study in which Catalan/Spanish bilinguals performed a picture-naming interference task (Costa et al., 1999). In the task, the pictures to be named were presented with superimposed words as distractors. The words could be written either in Catalan or in Spanish. In addition, these words could represent the picture name (identical condition) or an unrelated distractor (control condition). For example, in the identity condition participants were presented a picture with a dog and named it in Spanish while the word *gos* (meaning dog in Catalan) was concurrently presented. If competition takes place, participants would show a worse performance in this type of trials because a competitor lemma (*gos*) would receive activation both from the written word and the picture. However, the results showed the opposite pattern: participants were faster to name the pictures in the identical condition. The authors explained this facilitation effect based on the idea that competition was restricted to lemmas in the intended language so lemmas in the alternative language were not involved in lexical selection.

A second proposal upholds a language non-selective mechanism, in the sense that all the entries are considered for selection, regardless the language they belong to. The selection of the target language would be achieved by creating different activation levels for L1 and L2 items. For example, the model proposed by Poulisse and Bongaerts (1994) assumes a single lexicon for both bilingual's languages which functioning would be based on the spreading activation among its lexical items. Besides, lexical representations would be partially activated and they would compete during language production. Poulisse and Bongaerts argued that language selection would be carried out by increasing the activation level of the target language items in relation to the non-target language items. From this model, language cues would act on conceptual information to impact on the activation level of the lexical items. Specifically, the target language items would receive greater activation than the alternative language items.

Whereas Costa (2005) upholds that lexical competition in bilingual would be limited to the items belonging to the intended language, Poulisse and Bongaerts (1994) defend between-languages competition. However, both models propose a language selection mechanism on the basis of an evaluation of the lexical items activation.

Inhibitory perspectives

Within the perspectives that propose inhibitory processes in language selection one of the most important models is the Inhibitory Control model (IC model, Green, 1998). The IC model is a broad framework which can explain how bilinguals select between active representations in both languages at several levels of processing (e.g., lexical, semantic) in different linguistic domains (language comprehension and language production). According to the IC Model, bilingual language processing implies different levels of control. One type of control is achieved by "task schemas" which allow bilinguals to select a task rather than another from the many possible (reading words, translating words, etc.). This control is obtained by suppressing the competing task in favour of the intended task. A second type of control is located at the lexico-semantic level. Green proposes that each lexico-semantic representation has an associated language tag (e.g., L1 or L2) that exerts control by activating and inhibiting lexico-semantic representations of the language needed to perform the intended task. These two inhibitory mechanisms work together to let the bilinguals perform a specific task in one of their languages. An assumption of the IC model is that inhibition is reactive and proportional to the activation level of the words to be inhibited, so that more active non-target lemmas will be more inhibited. This assumption has been widely tested through the use of the language switching paradigm (e.g., Meuter & Allport, 1999) in which the presence of asymmetrical switching costs is taken as an index of inhibition. In their study, Meuter and Allport (1999) asked participants to name digits in either their L1 or L2. The language of naming varied in an unpredictable manner and it was signalled by the colour of the screen in which they were presented. There were non-switching trials, which required the response in the same language of the previous trial, and switching trials, which required the response in the alternative language of the previous trial. A switching cost was observed, since participants took longer to respond to switching trials as compared to non-switching trials. Moreover, the cost of switching was asymmetric: it took longer to switch into L1, the participants' dominant language, than to L2, their less dominant language. This asymmetry is clearly predicted by the IC model (1998); if inhibition is reactive and proportional to the amount of activation, more active non-target lemmas will be more inhibited. Thus, naming in L2 will lead to a strongly reactive inhibition of the L1 representations, so that later on participants will take longer to switch into this language (L1) to overcome inhibition.

The Bilingual Interactive Activation model (BIA model, Dijkstra & Van Heuven, 1998) is another relevant model that has aimed to account for language control in bilingual processing. According to this model language selection would be carried out by means an interactive process of activation and inhibition. This model assumes four levels of linguistic representations: letter features, letters, words and language nodes. The BIA model proposes that letter features and letters that are part of a word activate lexical candidates in all bilingual's languages in a non-selective way. These candidates also activate the language node to which they are connected depending on the language context and the activated lexical entries would compete for selection. In this model, inhibition is implemented by two mechanisms (a) lexical candidates inhibit other candidates from the same language (lateral inhibition) and, (b) language nodes inhibit the activation of lexical candidates from another language. The result of these activation and inhibition processes would lead to select the more activated lexical representation.

ELECTROPHYSIOLOGICAL CORRELATES OF LANGUAGE ACTIVATION AND INHIBITORY CONTROL IN LANGUAGE SELECTION

Although most of the bilingual processing research has been based on behavioural measures (Dijkstra, 2005), recently there is a growing interest in the use of techniques that allow to obtain online physiological measures of bilingual processing. For instance, the event-related brain potentials technique (ERPs), with a high temporal resolution (milliseconds), can give us information about of the time course of different linguistic processes in bilinguals.

To illustrate, there are two important ERP components broadly studied in bilingual language processing, the N400 and the N200. The N400 is negative potential peaking around 400 ms after the stimulus presentation, and located at parietal, temporal and occipital sites of the right hemisphere. This component is related to linguistic processing and it has shown to be sensitive to different aspects related to the semantic processing, for example, the semantic relation between words or the context effect on integration processes (see Kutas, Van Petten, & Kluender, 2006; for a review).

Researches also have focus on the N200 component, which can reflect the influence of the L1 on the L2 processing. The N200 component has been mainly related to response suppression or inhibition using the *go/no-go* paradigm. This paradigm has been also used to study the recall of conceptual, syntactic and phonological information in language production as well as comprehension (see Jansma, Rodriguez-Fornells, Möller, & Münte, 2004; for a review). Although the N200 is not properly a language-specific ERP effect, it has been associated to cognitive control and inhibitory effects in bilinguals (Moreno, Rodriguez-Fornells, & Laine, 2008).

ERPs have been mainly used to explore first language processing. However, recently this technique has been used to investigate cross-language interactions and the involvement of inhibitory processes in language selection in bilinguals. Therefore, some previous ERP studies have focused on homograph processing in bilinguals Elston-

Güttler, Paulmann, & Kotz, 2005; Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006; Paulmann, Elston-Güttler, Gunter, & Kotz, 2006). Kerkhofs et al. (2006) used a semantic priming paradigm to examine the effects of semantic and lexical context for interlingual homographs in Dutch-English bilinguals while reaction times (RTs) and ERPs were recorded. The participants performed an English lexical decision task in which the target words were preceded by single primes. To provide an English language context, the primes were always English words. Target words included interlingual homographs (e.g., "*stem*", meaning "voice" in Dutch), English control words or nonwords that were preceded by primes that were semantically related (e.g., "*root*") or unrelated (e.g., "*fool*") to the targets. The authors observed faster latencies for the homographs in the semantic related conditions than for those in the unrelated ones. In addition, in the ERPs they found lower amplitudes for homographs preceded by related primes. The authors suggested that both RTs and ERPs effects in the 350-500 ms time window after target onset supported the language nonselective lexical access and reflected processes of semantic integration.

TIME COURSE OF CONTROL PROCESSES IN LANGUAGE SELECTION

A still open research question refers to the time course of the control processes. Although a recent body of evidence suggests the presence of inhibitory processes in language selection (Kroll, Bobb, Misra, & Guo, 2008; Macizo, Bajo, & Martín, 2010) it is not clear when inhibition is overcome. Next, we expose the results of previous studies that have motivated our interest on this issue.

As we have referred before, interlexical homographs have been used to study cross-language activation and selection processes in bilinguals. If the two languages are activated in parallel, the presentation of interlingual homographs would produce interference since their two meanings will be activated and will compete for selection. Thus, to correctly select the target meaning, the irrelevant meaning has to be inhibited. However, there is an open debate in studies with monolingual and bilingual speakers on whether the activation of the irrelevant homograph meaning decays over time or instead it is inhibited (Altarriba & Gianico, 2003; Balota & Paul, 1996; Beauvillain & Grainger, 1987; Chwilla & Kolk, 2003).

Beauvillain and Grainger (1987) performed an experiment using a priming paradigm, in which English-French bilinguals read French words as primes, including homographs such as "*coin*" (meaning "*corner*" in French). Next, they performed a lexical decision task on English target words which were related or unrelated to the English meaning of the homographs. The results showed that bilinguals activated the meanings of the homographs in their two languages since facilitation was observed for target words related to the inappropriate meaning of the homograph prime words ("*coin-money*"). Nevertheless, this semantic priming effect was only observed when English targets were presented 150 ms after the onset of the French primes, disappearing when the prime-target onset asynchrony (SOA) reached 750 ms. This pattern of results suggests that bilinguals activated the two meanings of the homographs in early stages of processing but that this activation later disappeared. However, the reason why the inappropriate meaning became less active at a longer SOA was unclear. In Beauvillain and Grainger's experiment it was difficult to introduce a baseline condition that demonstrated that the absence of priming effects at a longer SOA was due to the inhibition of the non-target meaning and not to the automatic decay of the irrelevant meaning with time. In that study, the response was biased since the language context was just the language of the ambiguous words and there was not an unbiased control condition.

MODULATING FACTORS OF LANGUAGE ACTIVATION AND INHIBITORY CONTROL IN LANGUAGE SELECTION

We have seen that bilingual research has aimed to answer how bilinguals select the language they need when cross-language activation occurs (see Kroll & Tokowicz, 2005; for a review). Although there are a great number of studies showing that bilinguals activate their two languages, even when using only one, the non-selective activation of the two languages of the bilingual has not always been observed and it might depend on several aspects (Christoffels, De Groot, & Kroll, 2006; Ibáñez et al., 2010; Linck, Kroll, & Sunderman, 2009). In addition, the degree of between-language competition that follows this nonselective activation might depend on several factors, such as language proficiency and dominance (Costa & Santesteban, 2004; Elston-Güttler et al., 2005), the cognitive resources available to the bilingual (Ibáñez et al., 2010; Macizo & Bajo, 2006), the context in which the bilinguals are immersed or their particular experience with the language (see Kroll et al., 2006; for a review). Two of the mentioned factors are relevant for the current work: immersion in a second language environment and the expertise in translation.

Immersion in L2 context

Overall, between-language competition is easily observed in bilinguals who are continuously exposed to their native language (L1) when they are evaluated in their weaker language (L2). In this situation, it is reasonable to expect competition from the non-intended language (L1), first because it is the dominant language, and second because the environment favours its activation (an L1 speaking context). The existing literature on bilingual processing provides wide evidence of L1 activation in bilinguals immersed in L1 that perform L2 language production (Kroll et al., 2006; Marian & Spivey, 2003) and L2 language comprehension (Dijkstra, 2005; Dijkstra & Van Heuven, 2002; Macizo et al.,, 2010). However, L2 immersion might reduce between-language competition. The distinctive feature of an immersion environment is that individuals are visually and auditorily surrounded by their L2. In this situation the influence of L1 when performing an L2 linguistic task may be reduced.

Although little research has been done about the effect of L2 immersion, previous studies on this issue suggest that the immersion in an L2 context leads to a change in the way in which both L2 and L1 are processed. Link et al. (2009) compared the performance of two groups of native English speakers who were learning a second language (Spanish) in two different learning contexts. One group was studying Spanish in a classroom context and the other group was immersed in a Spanish environment during a semester studying abroad. The participants performed a translation recognition task and a verbal fluency task in L1 and L2. In the translation recognition task, participants were presented word pairs (an L2 word and an L1 word, e.g., *cara-face*) and they had to decide whether the two words were a correct translation pair. Among the pairs to be rejected there were pairs similar in lexical form to the Spanish word (e.g., *cara-card*), similar to the English translation (e.g., *cara-fact*), or related in meaning to the Spanish word (e.g., *cara-head*). Classroom learners showed interference in all three conditions, whereas the immersed group did not show lexical form interference. In addition, the results of the verbal fluency task showed that the immersed learners group produced a larger number of examples in Spanish and, critically, they produced significantly fewer examples in English, their L1. The pattern of results obtained by the authors in comprehension and production suggests that activation of L1 and L1 to L2 competition was weaker in participants immersed in L2 context.

Expertise in translation

The role of expertise in translation has been previously explored in relation to the linguistic and cognitive processes involved in translation and interpreting tasks (Christoffels & De Groot, 2005; Christoffels et al., 2006; Ibáñez et al., 2010; Macizo & Bajo, 2006). When translators perform translation tasks they have to comprehend and reformulate a given message expressed in one language into another language. Despite differences among the existing varieties of translation tasks, the main characteristic of the translation performance is that the translator has not only to understand and reformulate a message from one language to another, but also she or he has to maintain active their two languages and to switch continually between them. Therefore, translators have to manage the activation of two languages and be continuously coping with the interference coming from the parallel activation of the two languages in the translation task. Although inhibitory control has been suggested as the way bilinguals select the required language (e.g. Green, 1998), this mechanism does not seem appropriate for performing translation tasks since in these tasks one language has to be active to comprehend the input while the other has to be also active in order to simultaneously produce the output.

The results obtained by Ibáñez et al. (2010) suggest that bilinguals may differ in the way they negotiate their two (or more) languages. In their study, Ibáñez et al. asked professional translators to read and understand sentences, and repeat them in the language of presentation (Spanish: L1 or English: L2). To explore the non-selective activation of both languages they introduced cognate words (e.g., zebra/cebra, in English/Spanish, respectively) in the sentences, taking the possible cognate effect as an index of between-language activation. In addition, in order to explore the nature of the lexical selection mechanism, they adapted the language switching paradigm (e.g., Meuter & Allport, 1999) to a sentence reading task. Thus, the sentences were presented in Spanish (L1) or English (L2) in an unpredictable manner. The authors took the asymmetrical switching cost (larger switching cost to the dominant L1 than to the less dominant L2) as an index of inhibitory control. The results showed that translators were faster processing cognate words as compared to control words while they did not show asymmetrical language switching cost. These two results suggest that translators kept active their two languages without inhibiting any of them.

AIMS AND ORGANIZATION OF THE EXPERIMENTAL SECTION

The second part of the thesis comprises the experimental section that aims to investigate the objectives previously exposed. We investigate the involvement of inhibitory mechanisms on language selection in Spanish-English bilinguals (L1: Spanish; L2: English) by using a semantic relatedness judgment task in which word pairs of English words were presented including interlexical homographs as critical stimuli (e.g., *"pie"* means *foot* in Spanish and *cake* in English). The paradigm we used is an adaptation of the negative priming task developed in blocks of two trials, which allows us to take two different indexes or measures. On one hand, we will consider the interference effect in response to word pairs including homographs (i.e., first trial of the block) as an index of the non-selective activation of both meanings of a homograph. On the other hand, we will consider the delay to response to trials that require the reactivation of the irrelevant meaning of the homograph (i.e., second trial of the block), presented in a previous trial, as an index of the homograph non-target meaning inhibition. This task will be used along the whole experimental section.

The experimental section is developed along the Chapters III, IV, V and VI. In Chapter III we aim to investigate cross-language activation and inhibitory processes in language selection through homographs processing in Spanish-English bilinguals. If cross-language activation takes place, the presentation of a homograph will produce interference because of the activation of its two meanings. In these circumstances, inhibitory processes would be needed to select the target meaning. This chapter includes two experiments. Experiment 1 aims to gather evidence of the involvement of inhibitory processes to select the target meaning of an interlexical homograph using the task above referred including word pairs. The goal of Experiment 2 is to explore the presence of these processes when words are presented in isolation. The stimuli used in this experiment are the same as those in Experiment 1, but in this case the participants perform an English lexical decision.

Chapter IV aims to gather new evidence of the involvement of the processes of interest observed in Chapter III and to explore the cortical activity associated to the processing of homographs. We use a high temporal resolution technique as the event-related potentials recording adapting the semantic judgment task to the electroencephalogram recording. In this study we expect that cross-language activation and inhibitory processes are reflected on both behavioural and electrophysiological measures.

In Chapter V we investigate the time course of the inhibitory control processes.

In this chapter two experiments are including differing in the time interval that elapses from the moment when interference is produced by the non-selective activation of the two homograph meanings and the moment when inhibitory processes are needed to resolve between-representations competition.

The study included in the last empirical chapter of the present work (Chapter VI) aims to explore the influence of two important factors that may modulate bilingual language processing: the immersion in a second language environment and the expertise in translation. To evaluate the effect of these factors on cross-language activation and inhibitory processes in language selection, we tested three different groups of Spanish-English bilinguals differing in their language immersion context (i.e., L1 or L2) and in their experience in professional translation.

The third part of the thesis includes a general discussion chapter (Chapter VII). In this final chapter we present a general overview and discussion of the main empirical findings of the present dissertation and we include a brief outline about some future research questions. Finally we close the current work with Chapter VIII which contains appendices with the experimental stimuli and materials used in our studies.

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CHAPTER III

INHIBITORY PROCESSES IN LANGUAGE SELECTION: EVIDENCE FROM INTERLEXICAL HOMOGRAPHS[1]

This study examines how Spanish-English bilinguals select meanings of words that share the same orthography across languages but differ in meaning (interlexical homographs such as pie, meaning foot in Spanish). Bilingual participants were required to decide whether pairs of English words were related. Participants were slower to respond to homographs presented along with words related to the Spanish meaning of the homograph as compared to control words. More importantly, bilinguals were slower to respond when the English translation of the Spanish homograph meaning was presented after responding to homographs. This result suggests that bilinguals inhibited the irrelevant homograph meaning. Furthermore, the results of an additional control experiment, in which participants performed a lexical decision task, indicated that these inhibitory processes were observed even when critical words were presented in isolation. Overall, these results suggest that bilingual language selection in comprehension tasks involves inhibitory processes.

[1] The studies included in this chapter are part of the content of the paper published as Macizo, P., Bajo, T., & Martín, M. C. (2010). Inhibitory processes in bilingual language comprehension: Evidence from Spanish-English interlexical homographs. *Journal of Memory and Language*, *63*, 232-244.

INTRODUCTION

The main goal of the present study was to investigate language activation and language selection processes in bilinguals while processing interlexical homographs. Specifically, we wanted to gather evidence of the presence of inhibitory processes when bilinguals select the target meaning of an interlexical homograph.

In bilingual language processing research, homographs have been used as a strategy for studying the parallel activation of two languages (Beauvillain & Grainger, 1987; De Groot, Delmaar, & Lupker, 2000). Interlexical homographs are words with the same written form but different meaning in the two languages of the bilingual. So, a word such as "*pie*" means *cake* in English and *foot* in Spanish. If the bilinguals' two languages are activated during the processing of a given word then, bilinguals will activate all the homograph meanings regardless of the specific language context in which the homograph was presented. This fact raises the question of how they select the right language when both are active, and which is the control mechanism that allows them to select a representation between the competing alternatives in their two languages. In order to provide an answer to this question, several theoretical approaches have been put forward. One of these approaches proposes the existence of inhibitory processes in language selection. From this inhibitory perspective (the Inhibitory Control model, IC model, Green, 1998), cognitive control in language selection in bilinguals would be carried out by activation of the target language and the suppression of the non-target language items that compete for selection. Green proposes that, at the lexical level, each lemma has an associated language tag (e.g., L1 or L2) which specifies which units belong to each language. Although initially, lemmas of both languages are active, inhibitory control would be exerted on the tagged lemmas of the non-intended language. One of the assumptions of the IC model is that inhibition occurs in a reactive manner to the activation level of the words to be inhibited. This assumption has been largely tested through the language switching paradigm (Meuter & Allport, 1999) in which the switching cost has been taken as an index of inhibition. In their study, Meuter and Allport (1999) asked participants to name digits in either their L1 or L2 in an unpredictable manner depending on the color of the screen in which they were presented. There were non-switching trials, which required the response in the same language of the previous trial, and switching trials, which required the response in the alternative language of the previous trial. A switching cost was observed, since participants took longer to respond to switching trials relative to non-switching trials. Moreover, the cost of switching was asymmetric: it took longer to switch into the participants' dominant language (L1) that to the participants' weaker language. According to the IC model, if inhibition is reactive to the amount of activation of the competing lemmas, inhibition would more strongly act when the competing lemmas were those of the more dominant L1 language than when the competing lemmas were those of the L2 weaker language. Thus, naming in L2 will lead to a strong reactive inhibition of L1's representations, and this in turn would produce larger costs (more time) to switch into that language.

The involvement of inhibitory processes in language selection has been also explored by using interlexical homographs. If the parallel activation of two languages occurs, an interlexical homograph will led to interference because of the activation of the two homograph meanings. Thus, to correctly select the target meaning, the irrelevant meaning has to be inhibited. Beauvillain and Grainger (1987) performed an experiment using a priming paradigm, in which English-French bilinguals read French words as primes, including homographs such as "*coin*" (meaning "*corner*" in French). Next, they performed a lexical decision task on English target words which were related or unrelated to the English meaning of the homographs. The results showed that bilinguals activated the meanings of the homographs in their two languages since facilitation was observed for target words related to the inappropriate meaning of the homograph prime words ("*coin-money*"). Nevertheless, this semantic priming effect was only observed when English targets were presented 150 ms after the onset of the French primes, disappearing when the prime-target onset asynchrony (SOA) reached 750 ms. These results suggest that initially bilinguals activate the two meanings of homographs in early stages of processing but this activation later disappears. However, the reason why the inappropriate meaning became less activated at a longer SOA remains unclear. In the Beauvillain and Grainger experiment was difficult to introduce a baseline condition to demonstrate that the absence of priming effects at a longer SOA was due to the non-target meaning inhibition and not to the automatic decay of the irrelevant meaning as the time passed. In that study, the response is biased since the language context was just the language of ambiguous words, making difficult to introduce a control condition unbiased to either the French meaning or the English homograph meaning. In monolingual studies on homographs processing it has been shown that when a neutral context is introduced for each of the ambiguous word meanings, both meanings are active at both the short and longer SOAs (Gernsbacher & Faust, 1990). This result suggests that both ambiguous word meanings remain active and this activation doesn't decay as the time passes, in absence of a biasing context.

The main goal of the present study was to investigate language activation and language selection processes in bilinguals while processing interlexical homographs. Specifically, we wanted to gather evidence of the presence of inhibitory processes when bilinguals select the target meaning of an interlexical homograph by using a procedure similar to negative priming (Tipper & Driver, 1998). We used a relatedness judgment task in which participants had to decide whether or not pairs of English words were semantically associated. We selected this task since monolingual research has shown that inhibition occurs when participants are forced to select just one of the meanings of the ambiguous words (e.g., Balota & Paul, 1996). The word pairs were presented in English (the participants' L2) and only the English language was involved in the task. We presented the word pairs in L2 to increase the probability of observing activation and inhibition of the non-target meanings of the homograph since it would be easier to observe L1 interference processes on L2, what would in turn lead to the inhibition of L1 non-target representations. Since the task itself did not require the simultaneous activation of the two languages, any observed effect of homograph activation or inhibition will support the view that bilinguals activate both of their languages irrespective of the language needed to perform the task and that inhibitory processes are involved in language selection.

EXPERIMENT 1

In Experiment 1, pairs of two trials were presented (see Table 1). The first indexed the activation of the two homograph meanings while the second was employed to study the inhibition of the non-target homograph meaning. In the first trial, pairs of unrelated English words were presented and thus, the participant's correct response in the relatedness judgment task was "no". In the critical condition, an interlexical homograph (e.g., the word "*pie*", meaning "foot" in Spanish) was presented along with another word that was unrelated to the English meaning of the homograph but instead it was associated to the non-target Spanish meaning of the homograph ("*pie-toe*", homograph-unrelated condition). This condition was compared to a control condition in which a matched non-homograph word along with an unrelated English word was presented ("*log-toe*", control-unrelated condition). According to the non-selective view of bilingual language activation, the two homograph meanings will be activated and participants should take more time to respond in the homograph-unrelated condition as compared to the control-unrelated condition. Therefore, responses in the "*pie-toe*" trial might be slower when compared to the "*log-toe*" control trial. In the second trial, the correct response in the relatedness judgement tasks was "yes" since pairs of related words were presented. In the critical condition, the English translation of the non-target homograph meaning (e.g., "*foot*") was presented along with a related word (e.g., "*hand*"). This condition was compared to a control-related condition in which pairs of related words were presented for "yes" response (e.g., "*finger-hand*"). Longer response times in the translation-related condition as compared to control-related trials would indicate that the non-target meaning of the homograph was inhibited. In addition, if this inhibition is caused by the selection of the correct homograph meaning, it will be only present after the homograph-unrelated first trial. This pattern of results would extend the evidence of an inhibitory mechanism in bilingual language production to the selection of relevant homograph meanings in bilingual language comprehension.

Table 1. Sample word stimuli used in Experiment 1

Condition	Example
First Trial	
Homograph – Unrelated	pie toe
Control – Unrelated	log toe
Second Trial	
Translation – Related	foot hand
Control – Related	finger hand

Note. Homograph-unrelated condition: A Spanish-English interlexical homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word, *Translation-related condition*: The English translation of the Spanish homograph meaning was presented along with a related English word, *Control-related condition*: The English translation word was replaced by a control matched word. The translation-related condition and control-related condition were both preceded by either homograph-unrelated condition or control-unrelated condition in the first trial.

METHOD

Participants. Twenty-eight Spanish/English bilinguals (19 women and 9 men) from the English department at the University of Granada served as volunteers. They were paid for their participation. Their mean age was 22.73 (range from 18 to 29). Two were left-handed and 26 were right-handed. Before performing the actual experiment, the participants were asked to complete a language proficiency questionnaire on reading, writing, listening, and speaking in Spanish (L1) and English (L2). The participants were fluent in English but dominant in Spanish (see Table 4).

Design and Materials. In the current experiment blocks of two trials were presented, each trial consisting of English word pairs (see Appendix). An example of conditions used in the experiment is presented in Table 1. The two words in the first trial were always unrelated while word pairs in the second trial were always related. Two conditions were established in the first trial: (a) *Homograph-unrelated condition*: A Spanish-English interlexical homograph (e.g., "pie" meaning "foot" in Spanish) was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning (e.g., "toe"), (b) *Control-unrelated condition*: The homograph (e.g., "pie") was replaced by a non-homograph matched word (e.g., "log"). Two additional conditions were established in the second trial: (c) *Translation-related condition*: The English translation of the Spanish homograph meaning (e.g., "foot") was presented along with a related English word (e.g., "hand"), (d) *Control-related condition*: The English translation word (e.g., "foot") was replaced by a control matched word (e.g., "finger"). Therefore, a within-subjects factorial design was employed in which each participant was exposed to all experimental conditions. The presence of homographs was manipulated in the first trial and the presence of English translation of Spanish homograph meaning was manipulated in the second trial. In addition, the condition that preceded the second trials was manipulated so that, conditions (c) and (d) occurred after either condition (a) or (b).

Forty Spanish-English interlexical homographs were selected so that they had identical orthography in Spanish (Alameda & Cuetos, 1995) and English (Brysbaert & New, 2009) but different meaning across languages. The mean English meaning of the homographs was matched in lexical frequency, 395, SD = 1035 (Brysbaert & New, based on one-million count) with the Spanish meaning of the homographs, 410, SD = 1658 (Alameda & Cuetos, based on two-million count but computed here as one-million count), $t(39) = 0.05$, $p = .96$. The t-test comparison after transforming these frequencies to their natural log showed no differences between the English meaning of the homographs (1.47, SD = 0.97) and the Spanish meaning of the homographs (1.12, SD = 1.10), $t(39) = 1.43$, $p = .16$. For each homograph, an English word was selected so that it was unrelated to the English homograph meaning but it was semantically associated to the Spanish homograph meaning (homograph-unrelated condition). The mean forward associative strength and the mean backward associative strength between the Spanish homograph meaning (cue word) and its associated word (target word) was 0.17 (*SD* = 0.15), and 0.11 (*SD* = 0.18), respectively (Kiss, Armstrong, Milroy, & Piper, 1973; Nelson, McEvoy, & Schreiber, 1998). The forward associative strength or what is also called the cue-to-target strength gives the proportion of participants in a free association task who produce the target in the presence of the cue; while the backward associative strength gives this proportion in the target-to-cue direction. A new set of forty non-homographs were selected for the control-unrelated condition. Homographs and control words were matched for their lexical and semantic characteristics obtained from the Wilson's database (1988) and from the Brysbaert and New's database (2009) (see Table 2).

Table 2. Characteristics of critical stimulus in the study

First trial				
	Homograph	Control 1	*t*	*p*
Mean number of letters	4.15 (1.03)	4.15 (0.98)	0	1
Mean frequency	395 (1035)	1712 (7182)	1.31	.18
Mean concreteness	429 (154)	447 (146)	0.48	.64
Mean familiarity	549 (52)	554 (47)	0.5	.63
Mean meaningfulness	410 (69)	434 (74)	1.22	.24
Second trial				
	Translation	Control 2	*t*	*p*
Mean number of letters	4.60 (1.26)	4.95 (1.71)	1.09	.28
Mean frequency	289 (842)	357 (1537)	0.52	.61
Mean concreteness	442 (125)	488 (110)	1.88	.08
Mean familiarity	551 (41)	562 (33)	0.93	.36
Mean meaningfulness	419 (64)	446 (35)	1.67	.12

Note. Homograph: Spanish/English interlexical homographs used in the homograph-unrelated condition. *Control 1:* Control words that substituted homographs in the control-unrelated condition. *Translation:* English translations of Spanish homograph meanings used in the translation-related condition. *Control 2:* Control words that substituted translation in the control-related condition.

The forty English translations of the Spanish homograph meanings were used along with a new set of forty associated words for the translation-related condition in the second trial. In addition, the control-related condition was constructed by substituting the English translation word for a new matched control. The English translation words and the control words were matched for their lexical and semantic characteristics (Table 2).

The mean forward associative strength for the translation-related pairs and the control-related pairs was equated (0.17, *SD* = 0.16, and 0.18, *SD* = 0.24, respectively), $t(39) = 0.25$, $p = .80$. The mean backward associative strength for the translation-related pairs and the control-related pairs was equated also (0.11, *SD* = 0.18, and 0.13, *SD* = 0.19, respectively), $t(39) = 0.54$, $p = .59$. In addition, to further corroborate that related word pairs in the translation-related condition and in the control-related condition did not differ in semantic relatedness, we performed latent semantic analyses for each word pair in each condition with pairwise comparisons using a space of 300 factors. This analysis gives the semantic similarity of each pair of words used in the study. The results indicated that translation related pairs and control related pairs did not differ in semantic similarity (0.23, *SD* = 0.20, and 0.28, *SD* = 0.22, respectively), $t(39) = 1.31$, $p = .20$.

Four stimulus lists were created in order to counterbalance the items over conditions. Each list consisted of 40 blocks of two trials. In 20 blocks, the first trial was assigned to the homograph-unrelated condition whereas the first trial of the other 20 blocks was assigned to the control-unrelated condition. Ten homograph-unrelated trials and ten control-unrelated trials were followed by translation-related trials; the remaining trials were followed by control-related trials. The experimental conditions were counterbalanced across lists. To ensure that the second trial was not always preceded by an unrelated first trial, twenty filler blocks without interlexical homographs were also added to each list. The first trial of these blocks was composed by new pairs of related words (e.g., “tag price”) and the second trial comprised pairs of unrelated words (e.g., “bathroom dollar”). Therefore, the correct responses in the two trials of filler blocks was always “yes”-“no”, respectively. Experimental and filler blocks were randomized within lists; all words appeared only once on the list and each participant saw only one list. A short practice list preceded the experimental list. This list was constructed from a different word set arranged in 12 two-trial blocks with the same proportion of related and unrelated word pairs.

Procedure. The experiment was controlled by a Genuine-Intel compatible 2993

MHz PC using E-prime experimental software, 1.1 version (Schneider, Eschman, & Zuccolotto, 2002). Participants were tested individually. They were informed that they had to decide whether pairs of English words were related or unrelated. Participants were not informed about the presence of homographs with Spanish meanings. Instructions were given in English.

Participants were seated approximately 60 cm from the computer screen. Stimuli were presented in lower-case black letters (Courier New font, 18 point size) on a white background. At this viewing distance, one character subtended a vertical visual angle of 0.48 degrees and a horizontal visual angle of 0.67 degrees. Each block began with the presentation of two fixation crosses displayed at the center of the monitor for 600 ms. Right after the fixation crosses offset, the word pair comprising the first trial was presented. These words appeared in the positions as the fixation crosses were located. The homographs (homograph-unrelated condition) and their matched control words (control-unrelated condition) were the leftmost word of the pair whereas the unrelated words were the rightmost word of the pair. These pairs of words remained on the screen until a response was made by pressing either ‘m’ or ‘z’ key on the computer keyboard for “yes” responses (related word pairs) and “no” responses (unrelated word pairs), respectively. The ‘m’/‘z’ to ‘yes’/‘no’ assignment was counterbalanced across participants. Five-hundred milliseconds after the first trial offset the two-words comprising the second trial were presented. The English translation of the Spanish homograph meanings (translation-related condition) and their control matched words (control-related condition) were displayed on the left side whereas related words appeared on the right side. As in the first trial, these words remained on the screen until the participant pressed the key to respond.

RESULTS AND DISCUSSION

For the analyses of both RT and accuracy, two analyses of variance (ANOVAs) were performed comparing the two conditions in the first trial and the two conditions in the second trial. One analysis was performed with participants as the random variable (F_1), and another with items as the random factor (F_2). The incorrect responses (16.83% of the data) and the reaction times (RTs) exceeding a criterion of 2.5 *SD* for an individual participant's mean (2.46% of the data) were excluded from the latency analysis.

The ANOVA on RTs in the first trial showed that trials with interlexical homographs were responded to more slowly (1,993 ms, *SE* = 112) than non-homograph control trials (1,789 ms, *SE* = 95), $F_1(1, 27) = 28.41$, $p < .0001$, $F_2(1, 39) = 9.77$, $p < .01$ (see Table 3). In the second trial, the interaction between the type of trial (translation-related vs. control related) and the preceding first trial (homograph-unrelated vs. control-unrelated) was significant, $F_1(1, 27) = 4.55$, $p < .05$, $F_2(1, 39) = 5.35$, $p < .05$. After the homograph-unrelated trials, RTs were slower on the translation-related condition (1,687 ms, *SE* = 86) as compared to the control-related condition (1,437 ms, *SE* = 48), $F_1(1, 27) = 15.14$, $p < .001$, $F_2(1, 39) = 12.51$, $p < .001$. However, the translation-related and control-related conditions were responded to equally rapidly when they were preceded by control-unrelated trials (1,486 ms, *SE* = 73, and 1,413 ms, *SE* = 57, respectively), $F_1(1, 27) = 1.92$, $p > .05$, $F_2 < 1$.

Table 3. Mean reaction times in milliseconds (standard error into brackets) and percentage of errors for each condition in first and second trial (Experiment 1)

First Trial		
	Homograph – Unrelated	Control – Unrelated
Homograph – Unrelated	1993 (112)	1789 (95)
	28.57%	7.50%
Second Trial		
	Translation – Related	Control – Related
After Homograph – Unrelated	1687 (86)	1437 (48)
	18.57%	12.50%
After Control – Unrelated	1486 (73)	1413 (57)
	17.14%	14.29%

Concerning the analysis of errors, the ANOVAs on the data from the first trial showed that the homograph-unrelated condition produced more errors (28.57%, *SE* = 1.89) than the control-unrelated condition (7.50%, *SE* = 1.67), $F_1(1, 27) = 84.60$, $p < .001$, $F_2(1, 39) = 18.60$, $p < .001$. In the second trial, the percentage of errors was larger in the translation-related condition (17.85%, *SE* = 1.61) than in the control-related condition (13.39%, *SE* = 1.65) by participants, $F_1(1, 27) = 6.65$, $p < .05$, but not by items, $F_2(1, 39) = 1.30$, $p > .05$. The effect of the preceding first trial was not significant, F_1 and $F_2 < 1$. In addition, the Type of trial (translation-related vs. control related) x Preceding first trial (homograph-unrelated vs. control-unrelated) interaction did not reach significance, F_1 and $F_2 < 1$.

The results of this experiment suggest that after the activation of the two homograph meanings, the selection of the appropriate meaning involves inhibition of the non-target meaning. Thus, when the irrelevant meaning of the homograph became relevant in the second trial, the participants' response was delayed. However, a potential problem that was present in the experiment was the possible effect of the words that accompanied the critical words (homographs and the translations of the irrelevant homograph meanings) in the same trial. For example, the related word (e.g., "toe") in the homograph unrelated trial (e.g., "pie"-"toe") might determine the processing of the irrelevant homograph meaning ("foot") in the second trial. This possible effect might be similar in all second trials because "toe" was related with "foot" in the translation-unrelated trial (e.g., "foot"-"present") and with "finger" in the control-unrelated trial ("finger"-"present"). However, to explore this possibility, we performed an additional control experiment to further confirm that the inhibitory effect observed in the experiment was not due to the presence of related words that accompanied the critical words.

EXPERIMENT 2

The goal of Experiment 2 was to explore whether the inhibitory effect observed in Experiment 1 would be found when critical words are presented in isolation. To this aim we carried out a new experiment in which a new set of Spanish/English bilinguals (L1/L2, respectively) that did not take part in previous experiments performed an English lexical decision task. To have an index of between-language activation we compare the processing of the forty interlexical homographs from the homograph-unrelated condition (e.g., *pie*) relative to the processing of the forty control words that replaced them in the control-unrelated condition (e.g., *log*). More importantly, the English translation of the Spanish homograph meaning used in the translation-related condition (e.g., *foot*) appeared either after the homograph or after the control word. If participants inhibited the irrelevant homograph meaning they might be slower to respond when the translation appeared after the homograph than when it appeared after control words.

METHOD

***Participants*.** A new set of twenty-four Spanish/English bilinguals from the same pool as those participating in Experiment 1 took part as volunteers in this experiment (16 female, 8 male). Their mean age was 24.25 (*SD* = 3.79) and they were paid for their participation. Twenty-one participants were right-handed and three were left-handed. None of the participants had taken part in the previous experiment. The participant's characteristics are reported in Table 4.

Table 4. Characteristics of participants in the study

	Experiment 1	Experiment 2
Age (years)	22.73 (2.71)	24.25 (3.79)
Age starting L2 learning	9.75 (3.67)	8.37 (3.04)
Living in L2 speaking countries (months)	10.41 (13.85)	15.19 (11.15)
Language Proficiency Questionnaire		
L1 Speech fluency	9.07 (0.98)	9.62 (0.71)
L1 Speech comprehension	9.48 (0.70)	9.78 (0.51)
L1 Writing proficiency	9.21 (0.96)	9.62 (0.71)
L1 Reading proficiency	9.25 (0.75)	9.70 (0.55)
L2 Speech fluency	6.71 (1.76)	7.91 (0.92)
L2 Speech comprehension	7.61 (1.31)	8.25 (0.89)
L2 Writing proficiency	7.11 (1.03)	7.83 (0.93)
L2 Reading proficiency	7.36 (0.99)	8.16 (1.04)

Note. The self-report ratings in L1 (Spanish) and L2 (English) ranged from 1 to 10 where 1 was not fluent and 10 was very fluent. Standard deviations are reported into brackets.

Design and Materials. A within-subjects factorial design was employed in this experiment. We used the same critical words as those in Experiment 1 (i.e., the first word in the pair in both first trial and second trial): the forty interlexical homographs from the homograph-unrelated condition (e.g., *pie*) and the forty control words that replaced them in the control-unrelated condition (e.g., *log*). These control words were not related to any of the homograph meanings. In addition, we used the English translation of the Spanish homograph meaning used in the translation-related condition (e.g., *foot*) and it appeared either after the homograph or after the control word. To these experimental items we added eighty filler items about the same length for “no” responses. Sixty were English non-words and twenty were Spanish words. Experimental and filler items were randomized within lists. The lists contained the same proportion of “yes” and “no” responses, and we had special care that homographs were not preceded by the Spanish fillers to control for the effects of language shift between consecutive items (Von Studnitz & Green, 1997).

Procedure. The procedure was the same as that used in the previous experiment, with the only difference that in each trial a single string of letters was presented on the screen and participants were asked to perform an English lexical decision task in which they had to decide whether or not the presented letter strings were existing English words.

RESULTS AND DISCUSSION

For the analyses of RT, two analyses of variance (ANOVAs) were performed comparing the two conditions in the first trial and the two conditions in the second trial. The RTs exceeding a criterion of 2.5 *SD* for and individual participant’s mean (2.97% of the data) were excluded from the latency analysis.

The results of the ANOVA performed in the first trial showed that participants activated the two-homograph meanings because homographs were responded to more slowly (759 ms, $SE = 21$) than the control words (728 ms, $SE = 18$), $F(1, 23) = 3.67$, $p < .05$. In addition the ANOVA performed in the second trial showed that participants inhibited the irrelevant homograph meaning because the translations were responded to more slowly after homographs (721 ms, $SE = 17$) than after control words (675 ms, $SE = 17$), $F(1, 23) = 8.16$, $p < .01$.

The analyses performed on the errors showed that participants committed more errors with homographs (23.1%, $SE = 2.2$) than with control words (12.3%, $SE = 2.1$),

$F(1, 23) = 20.67$, $p < .001$. However, the percentage of errors was similar for translations preceded by homographs (4.6%, *SE* = 1.3) than for translations preceded by control words (3.8%, *SE* = 1.8), $F < 1$.

Therefore, the results of this experiment indicated that the inhibitory effect observed when participants processed the irrelevant homograph meaning after homographs is found even when critical words are presented in isolation. In Experiment 1 we selected a semantic relatedness judgment task because in the monolingual setting it has been shown that when participants are forced to select one meaning of the ambiguous words inhibition occurs, while this inhibitory process is not observed when they are doing either naming or lexical decision task. For example, other studies using lexical decision task in the bilinguals' L2 have failed to find convincing evidence for the activation and inhibition of the non-target homograph meaning (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). Dijkstra et al. (Experiment 1) asked Dutch L1/English-L2 bilinguals to perform an English lexical decision task which included interlingual homographs, cognates and English control words. Although cognates were recognized faster than control words, no differences were observed between homographs and their controls. Therefore, they did not find evidence for the activation of the non-target meaning of homographs when bilinguals performed a lexical decision task in their L2. Differences between Dijkstra et al.' study and results of Experiment 2 will be discussed further in the next section. The results we obtained in Experiment 2 further extend the findings of Experiment 1 by showing that after activating the two meanings of an interlexical homograph, the selection of the appropriated meaning involved the inhibition of the non-target meaning even when critical words are presented in isolation.

GENERAL DISCUSSION

The present study aimed to investigate language activation and language selection processes in bilinguals while processing interlexical homographs. In the study, Spanish/English bilinguals decided whether pairs of words were semantically related in

L2 (English). In Experiment 1, the participants activated the two homograph meanings because they responded more slowly when the word pair included an interlexical homograph whose Spanish meaning was related with the meaning of the presented English words. In addition, after activating the homograph two meanings, the participants inhibited the irrelevant meaning because they were slower to respond when this meaning became relevant in the next trial. These results agree with the existence of inhibitory processes in bilingual language selection.

In addition, the findings of the present study showed that the inhibitory effect of the irrelevant homograph meaning was not determined by the presence of related words in the first trial ("toe" in the homograph-unrelated condition). When critical words were presented alone in a lexical decision task, the homographs were responded to more slowly than control words and afterward the irrelevant homograph meaning was responded to more slowly than when it was preceded by control words. Previous studies have failed to observe differences between homograph and control words when Dutch/English bilinguals perform a lexical decision task in L2 (e.g., Dijkstra et al., 1998). It might be possible that the Spanish/English bilinguals of our study were less fluent in L2 than those Dutch/English bilinguals in the Dijstra et al.'s study so less fluent bilinguals presented more interference from their L1 in our study and later, they had to inhibit the irrelevant meaning to reduce interference.

The results obtained in the second trial of Experiments 1 and 2 are in agreement with the inhibitory perspective in language selection (IC model; Green, 1998). According to this model, bilinguals experience between-language competition and use inhibition to allow selection of the desired representations. Moreover, the inhibition is reactive because it can take place only after representations are activated. In the current study, bilinguals activated the Spanish representations of interlexical homographs even though the Spanish meaning was irrelevant to perform the task, and so the inhibition of the L1 irrelevant homograph meaning was required in order to select the appropriate response. The delay observed in the translation-related condition of the second trial reflected the time required to overcome this inhibition.

To sum up, the present research demonstrates that after activating the two meanings of an interlexical homograph, the bilinguals select the correct meaning by inhibiting the irrelevant interpretation. The presence of inhibitory processes to suppress the activation of the irrelevant meaning of between-language homographs might also be the mechanism underlying the selection of the correct homograph meaning in monolingual speakers (Balota & Paul, 1996; Chwilla & Kolk, 2003). The current study introduces a new strategy to corroborate the existence of inhibitory processes that might be also applied to the study of these processes in within-language research.

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CHAPTER IV

INHIBITORY PROCESSES IN HOMOGRAPH PROCESSING: EVIDENCE FROM RTs AND ERPs[1]

The present work examines the role of inhibitory mechanisms during the processing of interlexical homographs in bilinguals. We measured reaction times and electroencephalogram (EEG) while Spanish-English bilinguals decided whether pairs of English words were semantically related. The reaction times and the ERP amplitude were sensitive to cross-language activation in the presence of homographs as compared to control words. Moreover, the participants slowed their responses and showed more negative event-related brain potentials (ERPs) amplitude in response to the English translation of the Spanish homograph meaning after responding to homographs in the previous trial, as compared with the English translation preceded by the control trials. These results suggest the involvement of inhibitory processes in bilingual language selection.

[1] This paper is in preparation and co-authored by Pedro Macizo and Teresa Bajo..

INTRODUCTION

Many studies have shown that bilinguals activate their two languages even in conditions where they need only one language to communicate (non-selective language activation, see Dijkstra, 2005, for a review). Some of these studies have used interlexical homographs to seek evidence regarding the parallel activation of the bilinguals' two languages (De Bruijn, Dijkstra, Chwilla, & Schriefers, 2001; De Groot, Delmaar, & Lupker, 2000; Paulmann, Elston-Güttler, Gunter, & Kotz, 2006). Interlexical homographs are words that share lexical forms but have different meanings in the two languages (e.g. "*pie*" means *cake* in English and *foot* in Spanish). If both languages are active during the processing of homographs, the bilinguals would retrieve all of the homograph meanings regardless of the specific language context in which they are presented. This non-selective activation of the two meanings may either benefit or hinder performance depending on the task (De Groot et al., 2000; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). The results of different studies suggest that non-selective language activation may lead to between languages competition. However, bilinguals seem to be able to select the appropriate language when they are required to do so by the context. In this sense, a controversial question refers to which is the control mechanism that regulates the selection of the intended language when both are active.

Several approaches have been developed in order to provide an answer to this question. One of the most relevant theoretical approaches proposes the existence of inhibitory processes in language selection. From this perspective, the Inhibitory Control model (IC model, Green, 1998) maintains that language selection in bilinguals is achieved by means of the target language activation and the suppression of the non-target language items that compete for selection. Green proposes that, at the lexical level, each lemma has an associated language tag (e.g., L1 or L2) which specifies which units belong to each language. Although initially, lemmas of both languages are active, the language tags would exert inhibitory control on non-intended language lemmas. One of the IC model assumptions is that inhibition occurs in a reactive manner to the activation level of the words to be inhibited. This assumption has been tested largely through the language switching paradigm (Meuter & Allport, 1999) in which the switching cost has been taken as an inhibition index. In their study, Meuter and Allport (1999) asked participants to name digits in either their L1 or L2 in an unpredictable manner depending on the color of the screen in which they were presented. There were non-switching trials, which required the response in the same language of the previous trial, and switching trials, which required the response in the alternative language of the previous trial. A switching cost was observed, since participants took longer to respond to switching trials with regard to non-switching trials. Moreover, the switching cost was asymmetric: it took longer to switch into L1, the participants' dominant language. According with Green (1998), if inhibition is reactive to the amount of activation, more active non-target lemmas will be more inhibited. Thus, naming task in L2 will lead to a strongly reactive inhibition of L1's representations, taking more time to switch into that language.

The involvement of inhibitory processes in language comprehension has been explored with interlexical homographs (Beauvillain & Grainger, 1987; De Bruijn et al., 2001; Elston-Güttler, Paulmann, & Kotz, 2005; Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006; Macizo, Bajo, & Martín, 2010; Martín, Macizo, & Bajo, 2010; Paulmann et al., 2006). In their study, Kerkhofs et al. (2006) used a semantic priming paradigm to examine the effects of semantic and lexical context for interlingual homographs in Dutch-English bilinguals while reaction times (RTs) and ERPs were recorded. The participants performed an English lexical decision task in which the target words were preceded by single primes. To provide an English language context, the primes were always English words. Target words included interlingual homographs (e.g., "*stem*", meaning "voice" in Dutch), English control words or nonwords that were preceded by primes that were semantically related (e.g., "*root*") or unrelated (e.g., "*fool*") to the targets. The authors observed faster latencies for the homographs in the semantic related conditions than for those in the unrelated ones. In addition, in the ERPs they found lower amplitudes for homographs preceded by related primes. The authors suggested that both RTs and ERPs effects in the 350-500 ms time window after target onset supported the language nonselective lexical access and reflected processes of semantic integration.

Although most of the empirical evidence supporting inhibitory processes in bilingual processing comes from the language production domain (Costa & Santesteban, 2004; Meuter & Allport, 1999), little research has been done supporting these inhibitory processes in bilingual language comprehension. In this study we explore this issue in bilingual language comprehension using a procedure similar to the negative priming paradigm (Tipper & Driver, 1998) with interlexical homographs as critical stimuli. Specifically, we explored the non-selective activation of both homograph meanings and, moreover, the involvement of inhibitory processes in the selection of the homograph target meaning. To this aim, both reaction times and electrophysiological (EEG) measures were recorded.

We used a relatedness judgement task in which participants decided whether pairs of English words were related or not. The word pairs were presented in English (the participants' L2) to observe activation and inhibition of the homograph non-target meanings since the L1 activation (the participant's dominant language) will lead to interference when processing L2, and therefore L1 non-target representations would need to be strongly inhibited.

In our experiment, blocks of two trials were presented. The purpose of the first trial was to capture the interference produced by the activation of the homographs two meanings; and the purpose of the second trial was to capture the inhibition needed to overcome this inference. In the first trial, pairs of unrelated English words were presented. In the critical condition, an interlexical homograph (e.g., "*pie*", meaning "foot" in Spanish) was presented along with another word that was unrelated to the English meaning of the homograph (e.g., "*pie-toe*"). When a pair like "*pie-toe*" was presented, participants had to respond "no" since both words are unrelated in English. However, in this situation if the Spanish meaning of the homograph is also activated, the bilingual would experience interference because the irrelevant meaning of "*pie*" ("foot" in Spanish) is related to the English word "*toe*". We expected this interference to be associated with longer RTs and more negative ERPs around the N400 time window for the pairs containing homographs than for the control pairs as a consequence of the difficulty of retrieving the correct meaning of the homograph. In the second trial, pairs of English related words were also presented. In the critical condition, after presenting a homograph ("*pie-toe*") in the first trial, its English translation ("*foot*") appeared along with a related word (e.g., "*hand*") ("foot-hand" pair). If the L1 irrelevant homograph meaning was inhibited in the first trial, the retrieval of its English translation in the second trial would be costly and the RTs and ERPs might be sensitive to this inhibitory effect.

METHOD

Participants**.** Fourteen Spanish/English bilinguals from the University of Granada participated as volunteers (10 female, 4 male). Their mean age was 22.66 (*SD* = 1.63) and they were paid or received course credit for participating. Four were left-handed and ten were right-handed. The participants were native speakers of Spanish (L1) and fluent in English (L2). Before performing the experiment, we assessed their L2 fluency with a language proficiency questionnaire on listening, reading, vocabulary and grammar in English, the Oxford Quick Placement Test (QPT; Oxford, 2004). The QPT scores range from 0 to 100 graded from less to more English fluency. The participants' mean QPT score was 78.57 (*SD* = 5.93).

Design and Materials**.** The materials used in this experiment were the same as those used in Macizo et al. (2010) and Martín et al. (2010). Blocks of two trials were presented, each trial consisting of English word pairs. The two words in the first trial were always unrelated while word pairs in the second trial were always related (see Table 1). In the first trial there were *homograph-unrelated trials* in which a Spanish-English homograph was presented along with a word unrelated to the English meaning of the homograph but semantically associated with the Spanish meaning. In addition, there were *control-unrelated trials* in which the homograph was replaced by a non-homograph matched word and unrelated to the other word in the pair. In the second trial there were *translation-related trials* in which the English translation of the Spanish homograph meaning was presented along with a related English word. To evaluate the effect of the first trial on the second trial, the same translation-related word pairs were presented after both homograph trials and control trials. In addition, we added a control condition in which the English translation word was replaced by a control matched word. These control conditions appeared also after homograph and control trials.

Table 1. Sample word stimuli used in the experiment

Condition	Example
First Trial	
Homograph – Unrelated	pie toe
Control – Unrelated	log toe
Second Trial	
Translation – Related	foot hand
Control – Related	finger hand

Note. Homograph-unrelated condition: A Spanish-English interlexical homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word, *Translation-related condition*: The English translation of the Spanish homograph meaning was presented along with a related English word, *Control-related condition*: The English translation word was replaced by a control matched word. The translation-related condition and control-related condition were both preceded by either homograph-unrelated condition or control-unrelated condition in the first trial. Note that the second word of the example pairs described above was presented first in the sequence of events in the experiment.

Forty Spanish-English interlexical homographs were selected from NTC Spanish/English Cognates Dictionary (Nash, 1991) with identical orthography in

Spanish (Alameda & Cuetos, 1995) and English (Brysbaert & New, 2009) but different meaning across languages. The mean lexical frequency of the English homograph meaning was matched in lexical frequency, 395, *SD* = 1035 (Brysbaert & New, 2009, based on one-million count) with the Spanish meaning of the homographs, 410, *SD* = 1658 (Alameda & Cuetos, 1995, based on two-million count but computed here as one-million count), $t(39) = 0.05$, $p > .05$. The *t*-test comparison after transforming these frequencies to their natural log showed no differences between the English meaning of the homographs (1.47, *SD* = 0.97) and the Spanish meaning of the homographs (1.12, *SD* = 1.10), $t(39) = 1.43$, $p > .05$. For each homograph an English word was selected so that it was unrelated to the English homograph meaning but it was semantically associated with the Spanish homograph meaning (homograph-unrelated trials). The mean forward associative strength and the mean backward associative strength between the Spanish homograph meaning (cue word) and its associated word (target word) was 0.17, *SD* = 0.15, and 0.11, *SD* = 0.18, respectively (Kiss, Armstrong, Milroy, & Piper, 1973; Nelson, McEvoy, & Schreiber, 1998). A new set of forty non-homographs were selected for the control-unrelated trials. Homographs and control words were matched for their lexical and semantic characteristics obtained from the Wilson's database (1988) and from the Brysbaert and New's database (2009). The mean number of letters for homographs and control words was 4.15 (*SD* = 1.03) and 4.15 (*SD* = 0.98), respectively. The mean frequency for homographs and control words was 395 (*SD* = 1,035) and 1,712 (*SD* = 7,182), respectively. The mean concreteness value for homographs and control words was 429 (*SD* = 154) and 447 (*SD* = 146), respectively. The mean value of familiarity for homographs and control words was 549 (*SD* = 52) and 554 (*SD* = 47), respectively. The mean meaningfulness value for homographs and control words was 410 (*SD* = 69) and 434 (*SD* = 74), respectively. In addition, the forty English translations of the Spanish homograph meanings were used along with a new set of forty associated words for the translation-related word pairs in the second trial. The control-related condition was constructed by substituting the English translation word for a new matched control. The English translation word and the control word were matched for length (4.60, *SD* = 1.26, and 4.95, *SD* = 1.71, respectively), mean frequency (289, *SD* = 842, and 357, *SD* = 1,537, respectively), mean concreteness values (442, *SD* = 125, and 488, *SD* = 110, respectively), mean familiarity values (551, *SD* = 41, and 562, *SD* = 33, respectively), and mean meaningfulness values (419, *SD* = 64, and 446, *SD* = 35, respectively). The mean forward associative strength for the translation-related pairs and the control-related pairs was equated (0.17, *SD* = 0.16, and 0.18, *SD* = 0.24, respectively), $t < 1$. The mean backward associative strength for the translation-related pairs and the control-related pairs was equated also (0.11, *SD* = 0.18, and 0.13, *SD* = 0.19, respectively), $t < 1$.

Four stimulus lists were created. Each list consisted of 40 blocks of two trials. In 20 blocks, the first trial was assigned to the homograph-unrelated condition whereas the first trial of another 20 blocks was assigned to the control-unrelated condition. Ten homograph-unrelated trials and ten control-unrelated trials were followed by translation-related trials; the remaining trials were followed by control-related trials. The experimental conditions were counterbalanced across lists. To ensure that the participants could not predict the sequence of unrelated-related trials, twenty filler blocks were also added to each list, in a way that the first trial of these blocks was composed by new pairs of related words and the second trial comprised pairs of unrelated words. Experimental and filler blocks were randomized within lists; all words appeared only once on the list and each participant went through each of the four lists. A short practice list preceded the experimental lists. This list was constructed from a different word set arranged in 12 two-trial blocks with the same proportion of related and unrelated word pairs.

Procedure. Participants were tested individually in a soundproof room. They were seated approximately 60 cm from the computer screen. Experimenter communicated with the participants in their L1 (Spanish). However, participants were asked to read the instructions on the computer screen in their L2, and thus specific instructions for the experimental task were given in English. Stimuli were presented in lower-case black letters (Arial font, 34 point size) on a white background. Blocks of two trials were presented. The first trial began with a fixation point at the centre of the screen for 200 ms. Afterwards, the first word appeared for 500 ms in the centre of the screen. Right after the first word offset, the second word was presented (the homograph or the control word) in the centre of the screen. This word remained on the screen until a response was made. In any case, the presentation time was no longer of 2500 ms. Afterwards, the second trial started. The sequence of events in the first and second trial was the same. The second word in the second trial was either the English translation of the Spanish homograph meaning or the control word. Each block was separated from the next by a time interval for 1000 ms in with a row of dashes was presented. The participants were required to press a button to decide whether pairs of English words were related or unrelated (yes/no responses and right/left hands association was counterbalanced across participants).

Electrophysiological recording and analysis. The continuous electroencephalogram (EEG) was recorded from 30 tin electrodes mounted in an elastic cap (Quick-Cap, Neuroscan Inc.). The vertical and horizontal EOG were also recorded from bipolar pairs of electrodes placed above and below the left eye and on the outer canthi, allowing blink artefact to be corrected. Impedances were kept below 5 kΩ. Electrical signal were amplified with Neuroscan Synamps[2] with a sample rate of 250 Hz and a band-pass filter of 0.15-30 Hz. Eye movements were corrected from EEG using a methods consisting in regression analysis in combination with artefact averaging (Scan, 4.3). Individual epochs for each experimental condition ranged from -100 to 1,000 ms and only epochs associated with correct responses were included in the analyses. Average ERP waveforms were time-locked to the onset of each pair's second word. Baseline correction was performed in reference to prestimulus activity (100 ms before each pair's second word), and individual averages were digitally re-referenced to the global average activity.

Statistical analyses were performed over the mean amplitude on the 300 to 450 ms and 450 to 600 ms latency windows, according to previous findings on semantic processing with homographs and determined by visual inspection. In addition, the statistical analyses were carried out using seven regions of interest (ROIs): Left Frontal (F1, F3, FC1, FC3); Right Frontal (F2, F4, FC2, FC4); Left Central (C1, C3, CP1, CP3); Right Central (C2, C4, CP2, CP4); Left Parietal (P1, P3, PO3, PO5); Right Parietal (P2, P4, PO4, PO6); and Midline (FZ, FCZ, CZ, CPZ, PZ, POZ) (see Figure 1). Two separate ANOVAs were carried out, with a within-subject design, on first and second trials. We included the factors: Type of trial (homograph-unrelated vs. control-unrelated) and ROIs (7 regions described above), for the first trial; Type of trial (translation-related vs. control-related), Previous Trial (homograph-unrelated vs. control-unrelated) and ROIs (7 regions described above), for the second trial.

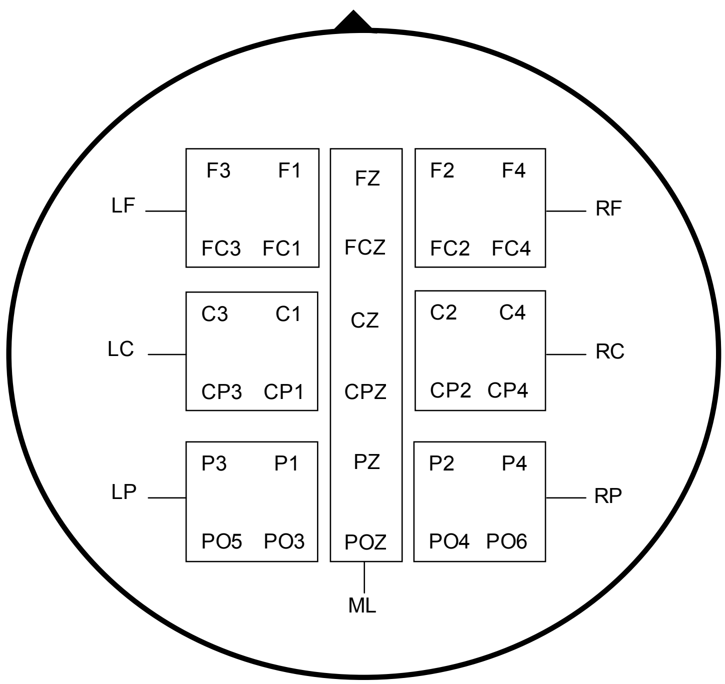

Figure 1. The head below shows regions of interest (ROIs) used in the statistical analysis. Each region on the scalp is labelled inside a square as follows: LF = Left Frontal; RF = Right Frontal; LC = Left Central; RC = Right Central; RP = Right Parietal; and ML = Midline.

RESULTS

Behavioural data. Analyses of variance (ANOVA) and *t*-test comparisons were performed on RT and accuracy, with participants (F_1 and t_1) and items (F_2 and t_2) as random variables. The incorrect responses (18.22% of the data) and the reaction times (RTs) exceeding a criterion of 2.5 *SD* for an individual participant's mean (3.11% of the data) were excluded from the latency analysis.

The analyses performed on the first trial showed that participants responded more slowly on trials with homographs (862 ms, $SD = 152$) than on control trials (783 ms, $SD = 192$), $F_1(1, 13) = 37.24$, $MSE = 40696$, $p < .001$, $F_2(1, 39) = 24.32$, $MSE = 9170$, $p < .001$.

The analyses performed on the second trial showed that the type of trial was significant (781 ms, $SD = 133$, and 752 ms, $SD = 119$, for the translation-related condition and control-related condition, respectively), by participants, $F_1(1, 13) = 6.91$, $MSE = 2079$, $p < .05$, but not by items, $F_2(1, 39) = 1.23$, $MSE = 6539$, $p > .05$. No significant interaction between factors was found, $F_1(1, 13) = 3.05$, $p > .05$, $MSE = 1974$, $F_2(1, 39) = 1.35$, $MSE = 20322$, $p > .05$. A series of *t*-test comparisons were performed in order to explore possible differences regarding to the previous trial that preceded. Significant differences were found between the translation-related conditions, preceded by unrelated-homograph trials and the unrelated-control trials (801 ms, $SD = 142$, and 760 ms, $SD = 126$, respectively), $t_1(14) = -2.47$, $p < .05$, but not by items, $t_2(39) = -1.37$, $p > .05$. No significant differences were found between the control-related conditions, preceded by unrelated-homograph trials and the unrelated-control trials (752 ms, $SD = 127$, and 752 ms, $SD = 116$, respectively), $t_1(14) = 0.01$, $p > .05$, $t_2(39) = -1.37$, $p > .05$ (see Figure 2).

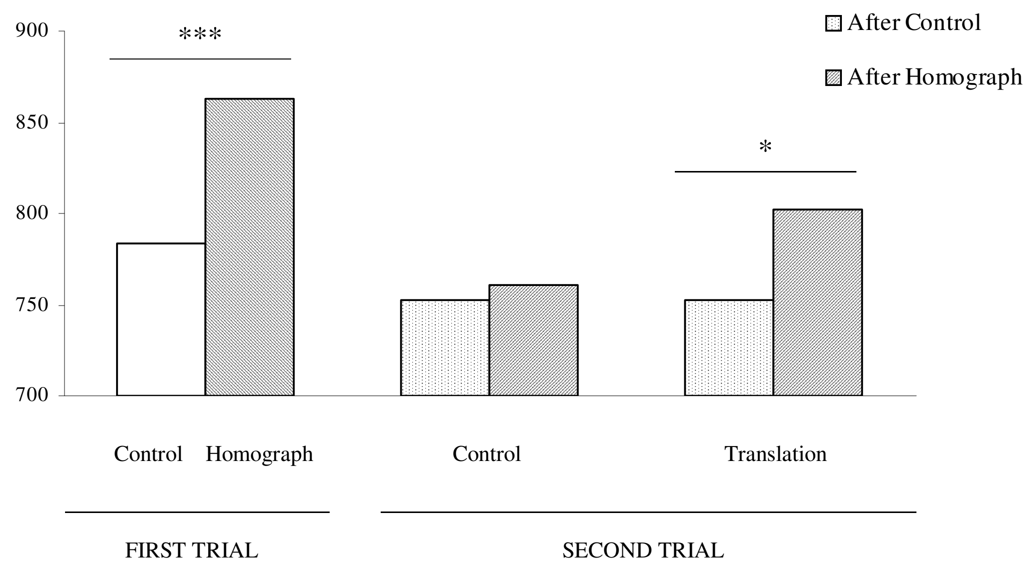

Figure 2. Mean reaction times in the first trial (homograph-unrelated condition versus control-unrelated condition), and mean reaction times in the second trial (between translation-related conditions and between control-related conditions) after either homograph-unrelated or control-unrelated first trials (***$p < .001$, *$p < .05$).

Accuracy. The ANOVA performed on the error data on the first trial showed larger errors percentages in the unrelated-homograph condition (21.42%, SD = 12.87) than in the unrelated-control condition (3.21%, SD = 3.42), by participants, $F_1(1, 13) = 41.66$, $MSE = 55.73$, $p < .001$, and by items, $F_2(1, 39) = 22.80$, $MSE = 34.52$, $p < .01$. However, no significant effect between conditions was found on the second trial on the error percentages (all ps > .05).

Electrophysiological data. The analyses performed on the first trial over the 300-450 ms time window showed a significant effect of the ROIs, $F(6, 13) = 4.63$, $p < .001$. No other effect or interaction was significant, $F < 1$. The analyses performed on the first trial over the 450-600 ms time window showed a significant interaction between Type of trial and ROIs, $F(6, 78) = 2.52$, $p < .05$. Further comparisons were performed for each region of interest to explore the spatial distribution of differences between conditions. These analyses showed that homographs were associated with more negative amplitudes as compared to control words on the midline region, $F(1, 13) = 5.16$, $p < .05$. The difference between homograph and control word pairs was not significant for the rest of regions (all *p*s > .05) (see Figure 3a).

The analyses carried out on the second trial over the 300-450 ms time window showed that the Condition x Previous Trial x ROIs second-order interaction was significant, $F(6, 78) = 2.31$, $p < .05$. In order to explore the spatial distribution of differences between conditions regarding to the previous trial that preceded, we performed separate analyses for both critical and control conditions. In this case, we introduced Condition (control-related after control-unrelated, vs. control-related after homograph-unrelated, for the control conditions; translation-related after control-unrelated, vs. translation-related after homograph-unrelated, for the critical conditions) and ROIs as within-subject variables. We found a significant effect of ROIs for the translation-related conditions, $F(6, 78) = 2.31$, $p < .05$. The Condition x ROIs interaction was marginal, $F(6, 78) = 1.97$, $p < .08$. In order to explore the spatial distribution of differences between conditions, we performed detailed comparisons for each region of interest. The results showed more negative amplitudes for the translation-related condition preceded by the homograph-unrelated condition, as compared with the translation-related condition preceded by the control-unrelated condition, in the right frontal region, $F(1, 13) = 9.26$, $p < .05$ (see Figure 3b). The analyses performed on the second trial over the 450-600 ms time window did not reveal any significant effect, $F < 1$.

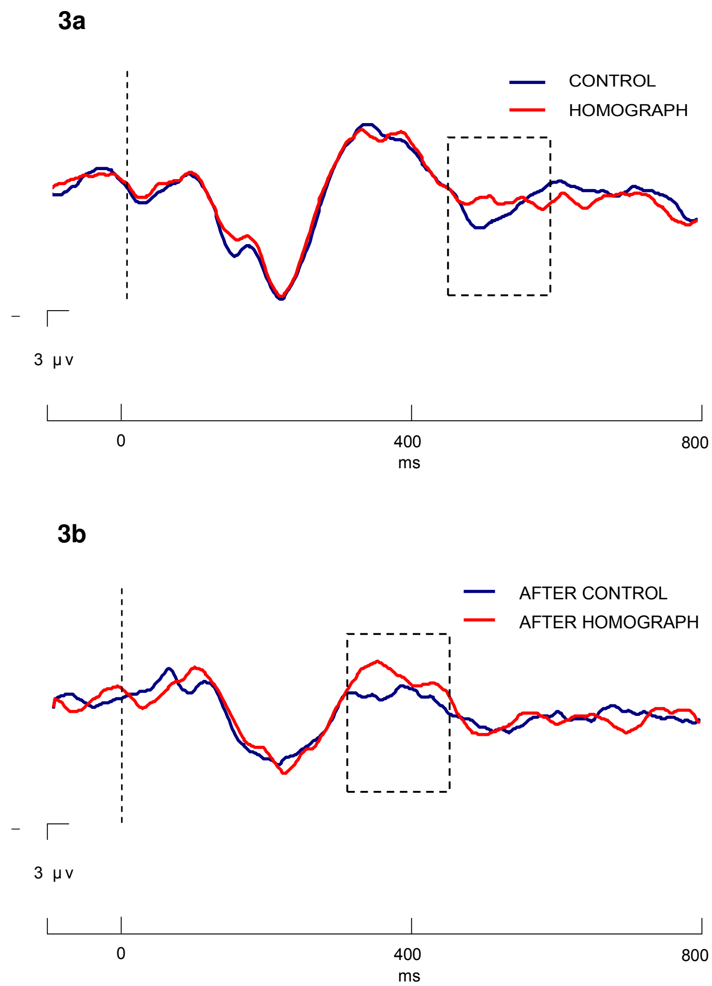

Figure 3. (3a) Grand average ERPs at a representative electrode site of the midline region (FCZ) for homographs-unrelated and control-unrelated conditions in the first trial in the 450-600 ms time window. (3b) Grand average ERPs at a representative electrode site of the right frontal region (FC2) for the translation-related conditions in the second trial in the 300-450 ms time window: after the homograph-unrelated condition and after the control-unrelated condition.

DISCUSSION

The present study aimed to explore behavioural and electrophysiological correlates of both non-selective activation and inhibition of the bilinguals' two languages during the processing of interlexical homographs. To this end, both reaction times and EEG were recorded while participants decided whether pairs of words were semantically related. The results of our study showed that the two meanings of an interlexical homograph were activated even though only the meaning in one language was relevant to perform the task. Cross-language activation was reflected on both reaction times and ERPs since the trials including homographs were responded to slower and elicited more negative amplitudes than control trials. These results are in agreement with previous work supporting the non-selective view of bilingual language processing (De Groot et al., 2000). Thus, the activation of the Spanish non-target homograph meaning competed with the target meaning of the homograph, making it difficult to give a correct response. The more negative amplitude in the N400 time window observed in the presence of homographs seems to be due to an increased difficulty in the semantic decision task because of the activation of the homograph irrelevant meaning. This ERP modulation associated with the processing of interlexical homographs was observed in the 450-600 ms time window on the midline region. This time course and scalp distribution of the electrophysiological differences is consistent with the results obtained in previous studies on interlingual homograph processing (De Bruijn et al., 2001; Paulmann et al., 2006). Moreover, the latency delay observed in the N400 component has been reported in previous studies in bilinguals as compared to monolinguals (Moreno, Rodriguez-Fornells, & Laine, 2008).

In addition, our results suggest that inhibitory processes are triggered to reduce between-language competition. According to the IC model (Green, 1998), the competition produced by the parallel activation of the two meanings of an interlexical homograph is resolved by inhibiting the non-target meaning. The results indicated that bilinguals slowed their responses when the Spanish meaning of the homograph became relevant on the next trial because of the time needed to overcome this inhibition. In addition, the slower RT was accompanied by more negative amplitudes when the homograph meaning was required after the presence of homographs. Based on the data of several studies (Kutas, Van Petten, & Kluender, 2006), we suggest that electrophysiological measures were sensitive to the difficulty of retrieving the Spanish meaning of the homograph since it was previously inhibited. The modulation of the ERP amplitude was observed in the 300-450 ms time window with a right frontal scalp distribution, which is in consonance with the latency and scalp distribution associated with cognitive control in bilingual language processing (Moreno et al., 2008). To sum up, these results support the non-selective view of bilingual processing and yield new evidence about the involvement of inhibitory processes in bilingual language comprehension.

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CHAPTER V

TIME COURSE OF INHIBITORY PROCESSES IN BILINGUAL LANGUAGE PROCESSING[1]

This study examines the time course of inhibitory processes in Spanish-English bilinguals, using the procedure described in Macizo, Bajo, and Martín (2010). Bilingual participants were required to decide whether pairs of English words were related. Critical word pairs contained a word that shared the same orthography across languages but differed in meaning (interlingual homographs such as pie, meaning foot in Spanish). In Experiments 1 and 2, participants were slower to respond to homographs presented along with words related to the Spanish meaning of the homograph as compared to control words. This result agrees with the view that bilinguals non-selectively activate their two languages irrespective of the language they are using. In addition, bilinguals also slowed their responses when the English translation of the Spanish homograph meaning was presented 500 ms after responding to homographs (Experiment 1). This result suggests that bilinguals inhibited the irrelevant homograph meaning. However, the inhibitory effect was not observed in Experiment 2 when the between-trial interval was fixed to 750 ms which suggests that inhibition decayed over time.

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[1] This paper was co-authored by Pedro Macizo and Teresa Bajo and published in the *British Journal of Psychology*, (2010).

INTRODUCTION

Many studies have shown that when fluent bilinguals comprehend words in their second language (L2), their first language (L1) representations are activated in parallel (see Dijkstra, 2005, for a review). This parallel activation assumption is referred to as the non-selective view of bilingual language processing, and it raises the question of how bilinguals access their lexical representations and of how they manage to control the activation of their two languages.

Research on bilingual language processing has used homographs to show parallel activation of the two languages (Beauvillain & Grainger, 1987; De Groot, Delmaar, & Lupker, 2000). Interlingual homographs are words with the same written form but different meaning in the two languages of the bilingual. For example, a word such as "*pie*" means *cake* in English, but it means *foot* in Spanish. If the two languages are activated during the processing of a given word by the bilinguals, all the homograph meanings will be activated regardless of the specific language context in which the homograph was presented. This non-selective activation of the two meanings may either benefit or hinder the participants' performance depending on the task. For example, Dijkstra, Van Jaarsveld, and Ten Brinke (1998; Experiment 3) asked Dutch/English bilinguals to decide whether or not a letter string was a word in English or Dutch. The material consisted of Dutch words, English words, Dutch/English interlingual homographs and non-words. The results showed that homographs were responded to more rapidly than non-homograph control words. Thus, in this experiment, the activation of the two homograph meanings caused an improvement in the participants' performance because the task required recognizing words irrespective of the language in which they were presented. In contrast, other studies have shown that the activation of the two meanings of an interlingual homograph may hinder the bilinguals' performance when just one of the meanings is required to perform the task. De Groot et al. (2000) asked Dutch/English bilinguals to decide whether pairs of words (a Dutch word and an English word) were translation equivalents. When pairs contained an interlingual homograph (e.g., "*glad*", meaning *slippery* in Dutch), participants slowed their response times as compared to matched controls. This was so because the non-target meaning activation (*slippery*) competed with the target meaning of the homograph (the English meaning of "*glad*": *pleased*).

The results described above suggest that non-selective language activation may lead to competition between the activated languages. However, bilinguals seem to be able to select the appropriate language and to switch between languages when the context requires it. But, how do they select the right language if both are active? What type of control mechanism allows them to overcome the negative influence of the two languages activation?

An appealing answer to this problem is the proposal that inhibitory processes are triggered to suppress the non-target representations. Within this perspective, the Inhibitory Control model (IC model, Green, 1998) upholds that language selection in bilinguals is achieved by means of the activation of the target language and the suppression of the irrelevant-competing non-target language representations. Concretely, the IC model proposes that at the lexical level of language production, each lemma has an associated language tag (e.g., L1 or L2) specifying the language of each unit. Although initially, lemmas from the two languages would be active, the language tags would exert inhibitory control over lemmas belonging to the non-intended language. An assumption of the IC model is that inhibition is reactive and proportional to the activation level of the words to be inhibited, so that more active non-target lemmas will be more inhibited. This assumption has been widely tested through the use of the language switching paradigm (e.g., Meuter & Allport, 1999) in which the presence of asymmetrical switching costs is taken as an index of inhibition. In their study, Meuter and Allport (1999) asked participants to name digits in either their L1 or L2. The language of naming varied in an unpredictable manner and it was signalled by the colour of the screen in which they were presented. There were non-switching trials, which required the response in the same language of the previous trial, and switching trials, which required the response in the alternative language of the previous trial. A switching cost was observed, since participants took longer to respond to switching trials as compared to non-switching trials. Moreover, the cost of switching was asymmetric: it took longer to switch into L1, the participants' dominant language, than to L2, their less dominant language. This asymmetry is clearly predicted by the IC model (1998); if inhibition is reactive and proportional to the amount of activation, more active non-target lemmas will be more inhibited. Thus, naming in L2 will lead to a strongly reactive inhibition of the L1 representations, so that later on participants will take longer to switch into this language (L1) to overcome inhibition.

Similarly, in language comprehension, the Bilingual Interactive Activation (BIA) model (Dijkstra & Van Heuven, 1998) proposes that control may be exerted by means of language nodes that would control the degree to which any given language is activated. These language nodes would act as language tags increasing the lexical activation of the appropriate language and simultaneously decreasing the activation of the non-target language lexical representations. Hence, between-language competition is solved by means of an inhibitory mechanism.

One way to study the involvement of inhibitory processes in language selection has been to use interlingual homographs. If the two languages are activated in parallel, the presentation of interlingual homographs would produce interference since their two meanings will be activated and will compete for selection. Thus, to correctly select the target meaning, the irrelevant meaning has to be inhibited. Recently, empirical evidence of the presence of inhibitory processes on bilingual language selection has been gathered from interlingual homographs (Macizo, Bajo, & Martín, 2010). In their study, Spanish/English bilinguals performed a relatedness judgement task including interlingual homographs (e.g., "*pie*", meaning "foot" in Spanish). In the experimental task pairs of English words were presented and participants had to decide whether or not they were semantically related. The participants were slower to respond to homographs presented along with words related to the irrelevant Spanish meaning of the homograph relative to control words (e.g., "*pie-toe*" vs. "*log-toe*"). Moreover, after responding to homographs, the participants responded more slowly when the following trial required activation of the irrelevant homograph meaning (e.g., "*foot-hand*" preceded by "*pie-toe*"). These results indicate that bilinguals activated both of their languages although only one was needed to perform the task, thus supporting the non-selective view of bilingual processing. In addition, these results suggest that bilinguals inhibited the irrelevant homograph meaning, thus supporting the presence of inhibitory processes in bilingual language selection.

In the present work, we also used interlingual homographs to study inhibitory processes on bilingual language processing. A still open question refers to the time course of these inhibitory processes. Although the results of previous studies suggest the existence of inhibitory processes that actively suppress the non-target meaning of an interlingual homograph (e.g., Macizo et al., 2010), it is not clear when inhibition is overcome.

Beauvillain and Grainger (1987) performed an experiment using a priming paradigm, in which English-French bilinguals read French words as primes, including homographs such as "*coin*" (meaning "*corner*" in French). Next, they performed a lexical decision task on English target words which were related or unrelated to the English meaning of the homographs. The results showed that bilinguals activated the meanings of the homographs in their two languages since facilitation was observed for target words related to the inappropriate meaning of the homograph prime words ("*coin-money*"). Nevertheless, this semantic priming effect was only observed when English targets were presented 150 ms after the onset of the French primes, disappearing when the prime-target onset asynchrony (SOA) reached 750 ms. This pattern of results suggests that bilinguals activated the two meanings of the homographs in early stages of processing but that this activation later disappeared. However, the reason why the inappropriate meaning became less active at a longer SOA was unclear. In Beauvillain and Grainger's experiment it was difficult to introduce a baseline condition that demonstrated that the absence of priming effects at a longer SOA was due to the inhibition of the non-target meaning and not to the automatic decay of the irrelevant meaning with time. In that study, the response was biased since the language context was just the language of the ambiguous words and there was not an unbiased control condition. Monolingual studies on homographs processing have shown that when a neutral context is introduced for each of the ambiguous word meanings, both meanings are active at short and longer SOAs (Gernsbacher & Faust, 1990). This pattern suggests that both ambiguous word meanings remain active and this activation does not decay as the time passes in the absence of a biasing context.

The aim of our study was to explore if the inhibitory mechanism involved in language selection extends in time. To this end we used an adapted version of the negative priming paradigm (Tipper & Driver, 1998) with interlingual homographs as the critical stimuli (Macizo et al., 2010). In order to explore the time span of inhibition we manipulated the time interval between the presentation of the interlingual homograph that should produce activation of the two meanings and interference of the irrelevant meaning, and the presentation of the irrelevant meaning of homograph which was supposed to be inhibited in the previous trial. The goal of Experiment 1 was to show that the consequences of inhibiting the irrelevant homograph meaning were present at 500 ms (Macizo et al., 2010) in order to later evaluate whether they were still present after 750 ms or if they disappear with time (Experiment 2).

EXPERIMENT 1

The goal of Experiment 1 was to find further support for the involvement of inhibitory processes in bilingual language processing. We used the experimental task described by Macizo et al. (2010). In this task pairs of English words were presented and participants decided whether or not they were semantically related (yes/no response). We used a relatedness judgement task which has been previously used in the context of bilingual research (Ota, Hartsuiker, & Haywood, 2009). We selected this task because monolingual research has shown that inhibition occurs when participants are forced to select just one meaning of the ambiguous words (e.g., Balota & Paul, 1996). The words pairs were presented in English (the participants' L2) in order to observe activation and inhibition of the non-target meaning of the homographs. Inhibitory models of language control predict (Green, 1998) that inhibition should be stronger when the competing language is also stronger (L1), that is, there should be more interference from L1 when responding to L2 than vice versa. In turn, this interference would lead to the inhibition of L1 non-target representations. Since the task did not require the simultaneous activation of the two languages, any observed effect of homograph activation or inhibition will support the view that bilinguals operate in a non-selective manner.

The task was carried out in blocks of two trials. The first trial aimed to capture L1 activation when bilinguals processed L2 words, while the second trial aimed to capture the inhibition needed to overcome inference. In the first trial, pairs of unrelated English words were presented, so the participants correct response was "no". In the critical condition, an interlingual homograph (e.g., "*pie*", meaning "foot" in Spanish) was presented along with another word that was unrelated to the English meaning of the homograph but related to the Spanish meaning (e.g., "*pie-toe*"). When a pair like "*pie-toe*" was presented, participants had to respond "no" since both words are unrelated in English. This condition was compared to a control condition in which a matched non-homograph word along with an unrelated English word was presented (e.g., "*log-toe*"). If the irrelevant homograph meaning was activated, bilinguals would take longer to respond in the homograph-unrelated condition than in the control-unrelated condition. This result would support the non-selective view of bilingual processing. In the second trial, pairs of English related words were presented, so that the participant's correct response was "yes". In the critical condition, the English translation of the non-target homograph meaning (e.g., "*foot*") was presented along with a related word (e.g., "*hand*"). This condition was compared to a control-related condition in which a matched related word was presented along with an English word (e.g., "*finger-hand*"). If the L1 irrelevant homograph meaning was inhibited in the first trial, it would take longer to respond when that meaning is required in the second trial. Thus, longer response times will be observed in the translation-related condition as compared to the control-related trials (e.g., "*foot-hand*" preceded by "*pie-toe*").

METHOD

***Participants*.** Sixteen Spanish/English bilinguals from the English department at the University of Granada participated in the experiment (11 female, 5 male). Their mean age was 23.50 (*SD* = 2.55) and they were paid or received course credit for their participation. Fourteen participants were right-handed and two were left-handed. The participants were native speakers of Spanish (L1) and fluent in English (L2). We assessed their L2 fluency with the Oxford Quick Placement Test (QPT; Oxford, 2004), a language proficiency test that assesses English proficiency on listening, reading, vocabulary and grammar. The QPT scores range from 0 to 100. The participants also completed a self-rating questionnaire about their subjective perception of their speech fluency, speech comprehension, writing and reading skills. The questionnaire was also intended to obtain information about their language history and experience in L1 and L2. Both tests were completed before performing the experiment. The participant's characteristics are reported in Table 1.

Table 1. Characteristics of participants in the study

	Experiment 1	Experiment 2
Age (years)	23.50 (2.55)	24.93 (5.63)
Age starting L2 learning	7.87 (3.24)	9.00 (1.77)
Living in L2 speaking countries (months)	14.00 (7.05)	14.18 (13.96)
Quick Placement Test		
Score	72.18 (12.46)	67.93 (11.13)
Language Proficiency Questionnaire		
L1 Speech fluency	9.56 (0.81)	9.86 (0.35)
L1 Speech comprehension	9.68 (0.60)	9.80 (0.41)
L1 Writing proficiency	9.43 (0.81)	9.93 (0.25)
L1 Reading proficiency	9.50 (0.89)	9.86 (0.35)
L2 Speech fluency	7.56 (1.15)	7.66 (0.89)
L2 Speech comprehension	7.87 (1.36)	8.00 (1.00)
L2 Writing proficiency	7.43 (1.26)	7.40 (1.35)
L2 Reading proficiency	7.81 (1.27)	8.00 (1.06)

Note. The self-report ratings in L1 (Spanish) and L2 (English) ranged from 1 to 10 where 1 was not fluent and 10 was very fluent. The QPT scores ranged from 0 to 100 graded from less to more English fluency. Standard deviations are reported into brackets.

Design and Materials. In the present study blocks of two trials were presented, each trial consisting of English word pairs. The two words in the first trial were always unrelated while word pairs in the second trial were always related. Two conditions were

established in the first trial (see Table 2): (a) *Homograph-unrelated condition*: A Spanish-English interlingual homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, (b) *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word which was unrelated to the other word in the pair. Another two conditions were established in the second trial: (c) *Translation-related condition*:

The English translation of the Spanish homograph meaning was presented along with a related English word, (d) *Control-related condition*: The English translation word was replaced by a control matched word. Consequently, a within-subjects factorial design was employed in which each participant was exposed to all experimental conditions. The presence of homographs was manipulated in the first trial, and the presence of English translation of Spanish homograph meanings was manipulated in the second trial. In addition, the condition that preceded the second trial was manipulated so that, conditions (c) and (d) occurred after either condition (a) or (b).

Table 2. Sample word stimuli used in the experiments

Condition	Example 1	Example 2
First Trial		
Homograph – Unrelated	pie toe	red tennis
Control – Unrelated	log toe	dark tennis
Second Trial		
Translation – Related	foot hand	net ball
Control – Related	finger hand	hit ball

Note. Homograph-unrelated condition: A Spanish-English interlingual homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word, *Translation-related condition*: The English translation of the Spanish homograph meaning was presented along with a related English word, *Control-related condition*: The English translation word was replaced by a control matched word. The translation-related condition and control-related condition were both preceded by either homograph-unrelated condition or control-unrelated condition in the first trial.

Forty Spanish-English interlingual homographs were selected from NTC Spanish/English Cognates Dictionary (Nash, 1997) with identical orthography in

Spanish (Alameda & Cuetos, 1995) and English (Kucera & Francis, 1967) but different meaning across languages. The mean English meaning of the homograph was matched in lexical frequency, 448.75, *SD* = 1359.40 (Kucera & Francis, 1967; based on a one-million count) with the Spanish meaning of the homograph, 410.41, *SD* = 1657.79 (Alameda & Cuetos, 1995; based on a two-million count but computed here as one-million count). For each homograph an English word was selected so that it was unrelated to the English homograph meaning but it was semantically associated to the Spanish homograph meaning (homograph-unrelated condition). The mean forward associative strength between the Spanish homograph meaning (cue word) and its associated word (target word) was 0.17, *SD* = 0.15 (Kiss, Armstrong, Milroy, & Piper, 1973; Nelson, McEvoy, & Schreiber, 1998). The forward associative strength or what is also called the cue-to-target strength gives the proportion of participants in a free association task who produce the target in the presence of the cue. A new set of forty non-homographs were selected for the control-unrelated condition. Homographs and control words were matched for their lexical and semantic characteristics obtained from the Wilson's database (1988). The mean number of letters for homographs and control words was 4.15 (*SD* = 1.03) and 4.15 (*SD* = 0.98), respectively. The mean frequency (Kucera & Francis, 1967) for homographs and control words was 448.75 (*SD* = 1,359.40) and 447.10 (*SD* = 1,486.56), respectively. The mean concreteness value for homographs and control words was 429.33 (*SD* = 154.02) and 447.33 (*SD* = 146.37), respectively. The mean value of familiarity for homographs and control words was 548.75 (*SD* = 52.06) and 554.13 (*SD* = 47.46), respectively. The mean meaningfulness value for homographs and control words was 410.18 (*SD* = 68.77) and 434.18 (*SD* = 74.39), respectively.

The forty English translations of the Spanish homograph meanings were used along with a new set of forty associated words for the translation-related condition in the second trial. In addition, the control-related condition was constructed by substituting the English translation word for a new matched control. The English translation word and the control word were matched for length (4.60, *SD* = 1.26, and

4.95, *SD* = 1.71, respectively), mean frequency (277.38, *SD* = 1147.18, and 638.13, *SD* = 3367.10, respectively), mean concreteness values (442.33, *SD* = 125.42, and 487.94, *SD* = 110.26, respectively), mean familiarity values (551.43, *SD* = 41.79, and 562.29, *SD* = 33.38, respectively), and mean meaningfulness values (419.00, *SD* = 64.11, and 446.50, *SD* = 35.50, respectively). The mean associative strength for the translation-related pairs and the control-related pairs was also equated (0.17, *SD* = 0.16, and 0.18, *SD* = 0.24, respectively).

Four stimulus lists were created in order to counterbalance the items over conditions. Each list consisted of 40 blocks of two trials. In 20 blocks, the first trial was assigned to the homograph-unrelated condition whereas the first trial of another 20 blocks was assigned to the control-unrelated condition. Ten homograph-unrelated trials and ten control-unrelated trials were followed by translation-related trials; the remaining trials were followed by control-related trials. The experimental conditions were counterbalanced across lists. Twenty filler blocks were also added to each list to avoid the predictable sequence of "no"-"yes" responses. The first trial of these blocks was composed by new pairs of related words and the second trial comprised pairs of unrelated words. Experimental and filler blocks were randomized within lists; all words appeared only once on the list and each participant saw only one of the four lists. A short practice list preceded the experimental lists. This list was constructed from a different set of words arranged in 12 two-trial blocks with the same proportion of related and unrelated words pairs.

Note that the materials and procedures were constructed so that the critical comparisons in the experiment are within trials involving the same type of yes/no response. In trial 1 the critical comparison between homograph-unrelated condition and control-unrelated condition was associated to "no" responses. In trial 2, the critical comparison between translation-related condition and control-related condition was associated to "yes" responses. Moreover, the possible effect of changing responses between trials was kept constant so that the "after homograph-unrelated" condition and the "after control-unrelated" condition always involved the same change of response relative to the previous trial.

Procedure. The experiment was controlled by a Genuine-Intel compatible 2993 MHz PC using E-prime experimental software, 1.1 version (Schneider, Eschman, & Zuccolotto, 2002). Participants were tested indidually. Stimuli were presented in lower-case black letters (Courier New font, 18 point size) on a white background. The participants were seated approximately 60 cm from the computer screen. At this viewing distance, one character subtended a vertical visual angle of 0.48 degrees and a horizontal visual angle of 0.67 degrees. Blocks of two trials were presented. The first trial began with a fixation point consisting of two crosses displayed in the same line at the center of the screen for 600 ms. Afterwards, the word pair for the first trial appeared in the positions where the fixation crosses were located. The homographs (homograph-unrelated condition) and their matched control words (control-unrelated condition) appeared on the left side whereas the unrelated words were displayed on the right side. This word pair remained on the screen until a response was made. Five-hundred milliseconds after the participant's response to the first trial, the word pair for the second trial was presented. As in the first trial, these words remained on the screen until the participant's response. The English translation of the Spanish homograph meanings (translation-related condition) and their control matched words (control-related condition) were displayed on the left side whereas related words appeared on the right side. The participants were informed that they had to decide whether English word pairs were related or unrelated by pressing the "m" and "z" keys on the computer keyboard for related and unrelated responses, respectively. Participants were not informed about the presence of homographs across languages.

RESULTS AND DISCUSSION

Analyses of variance (ANOVA) and *t*-test comparisons were performed on RT and accuracy, with participants (F_1 and t_1) and items (F_2 and t_2) as random variables. The incorrect responses (18.35% of the data) and the reaction times (RTs) exceeding a criterion of 2.5 *SD* for an individual participant's mean (2.77% of the data) were excluded from the latency analysis.

Reaction Times**.** The analyses performed on the RT data in the first trial showed that participants responded more slowly in trials where homographs were presented (2,057 ms, *SE* = 124) than in control trials (1,802 ms, *SE* = 101), $F_1(1, 15) = 19.44$, $MSE = 384996$, $p < .001$, $F_2(1, 37) = 10.40$, $MSE = 144269$, $p < .01$. The analyses on the second trial showed that the interaction between the type of trial (translation-related condition vs. control-related condition) and the preceding first trial (homograph-unrelated vs. control-unrelated condition) was significant, $F_1(1, 15) = 4.99$, $MSE = 26498$, $p < .05$, $F_2(1, 36) = 5.08$, $MSE = 167709$, $p < .05$. There were no differences between the translation-related condition and the control-related condition when they were preceded by control-unrelated trials (1,526 ms, *SE* = 74, and 1,416 ms, *SE* = 83, respectively), $t_1(15) = -1.97$, $p > .05$, $t_2(38) = 0.21$, $p > .05$. However, significant differences were found between the translation-related condition and the control-related condition when they were preceded by homograph-unrelated trials (1,773 ms, *SE* = 92, and 1,425 ms, *SE* = 41, respectively), $t_1(15) = -4.54$, $p < .001$, $t_2(37) = -3.76$, $p < .001$ (see Table 3).

Table 3. Mean reaction times in milliseconds (standard error into bracket) and percentage of errors for each condition in first and second trial (Experiment 1)

First Trial		
	Homograph – Unrelated	Control – Unrelated
Homograph – Unrelated	2057 (124)	1802 (101)
	29%	8%
Second Trial		
	Translation – Related	Control – Related
After Homograph – Unrelated	1773 (92)	1425 (41)
	18%	18%
After Control – Unrelated	1526 (74)	1416 (83)
	18%	16%

Accuracy. The ANOVA performed on the error data in the first trial showed that participants made more errors in the homograph-unrelated condition (29.37%, SE = 2.45) than in the control-unrelated condition (8.43%, SE = 2.91), $F_1(1, 15) = 56.53$, $MSE = 169.95$, $p < .001$, $F_2(1, 39) = 9.37$, $MSE = 9702.90$, $p < .01$.

The analyses performed on the second trial did not show differences in error percentages either with regard to the type of trial, F_1 and $F_2 < 1$, or to the preceding first trial, $F_1 < 1$, $F_2(1, 39) = 2.94$, $MSE = 5743.60$, $p > .05$. Moreover, the interaction between both factors was not significant, $F_1 < 1$, $F_2(1, 39) = 1.11$, $MSE = 3982.20$, $p > .05$.

The results of this experiment showed that the two meanings of an interlingual homograph were activated even though its meaning in one language was irrelevant to perform the task. Bilinguals took more time to respond to the homograph-unrelated condition than to the control-unrelated condition because of the activation of the non-target meaning. In addition, participants were slower to respond to translation-related trials as compared to control-related trials after responding to pairs containing homographs. These results indicate that to correctly select the appropriate homograph meaning, the irrelevant meaning of the homograph was inhibited. Participants needed more time to respond because they had to overcome inhibition when the Spanish homograph meaning became relevant in the critical condition of the second trial.

The pattern of results of this experiment replicates the results obtained by Macizo et al. (2010) in their study. The interference effect observed in the first trial is in agreement with previous work supporting the non-selective view of bilingual language processing (De Groot et al., 2000). The results obtained in the second trial suggest that participants used inhibitory processes to reduce between-language competition. Inhibition of the L1 irrelevant homograph meaning is required in order to select the appropriate response. Thus, participants might need time to overcome this inhibition when the Spanish homograph meaning becomes relevant in the second trial.

EXPERIMENT 2

The goal of Experiment 2 was to explore the time course of the inhibitory effect observed in Experiment 1. Specifically, we wanted to test for how long inhibition extended in time. In Experiment 1, the time interval between the participants' responses to the first trial and the second trial was fixed at 500 ms. In Experiment 2, we extended the time interval to 750 ms. Our predictions were that as in Experiment 1, we would observe slower reaction times to homographs when responding to the first trial since the interference caused by the non-selective activation of the two homograph meanings would be present, however longer reaction times to the critical condition of the second trial (irrelevant meaning of the homograph) would be observed only as long as the inhibition of the homograph meaning was still present.

METHOD

Participants. A new set of sixteen Spanish/English bilinguals from the same pool as those participating in Experiment 1 took part as volunteers in this experiment (9 female, 7 male). Their mean age was 24.93 (SD = 5.63) and they were paid for their participation. Fifteen participants were right-handed and one was left-handed. All participants completed the self-rating questionnaire and the QPT. The participant's characteristics are reported in Table 1. None of the participants had taken part in the previous experiment. *T*-test comparisons showed that participants in this experiment did not differ in their mean age, age starting L2 learning, months living in L2 speaking countries, L1 fluency, L2 fluency and QPT scores from participants of Experiment 1 (all p values > .05).

Design and Materials. The same within-subjects factorial design used in the previous experiment was employed in this experiment. Both the materials and conditions employed in this experiment were exactly the same as those used in Experiment 1.

Procedure. The procedure was the same used in the previous experiment, with the only difference regarding the time interval between the response given in the first trial and the presentation of word pairs in the second trial. In this case, the word pairs in the second trial were presented 750 ms after a response was given to the first trial.

RESULTS AND DISCUSSION

Analyses of variance (ANOVA) and *t*-test comparisons were performed on RT and accuracy, with participants (F_1 and t_1) and items (F_2 and t_2) as random variables.

The incorrect responses (21.09% of the data) and the reaction times (RTs) exceeding a criterion of 2.5 *SD* for an individual participant's mean (2.67% of the data) were excluded from the latency analysis.

Reaction Times. The analyses performed on the RT data to the first trial showed that participants responded more slowly to trials with homographs (2,090 ms, *SE* = 160) than to control trials (1,896 ms, *SE* = 160), $F_1(1, 15) = 6.30$, *MSE* = 775609, $p < .05$, $F_2(1, 38) = 5.99$, *MSE* = 481624, $p < .05$. The analyses on the second trial showed that the interaction between the type of trial (translation-related condition vs. control-related condition) and the preceding first trial (homograph-unrelated vs. control-unrelated condition) was not significant, F_1 and $F_2 < 1$. There were no differences between the translation-related condition and the control-related condition when they were preceded by control-unrelated trials (1,508 ms, *SE* = 144, and 1,451 ms, *SE* = 107, respectively), t_1 and $t_2 < 1$, nor between the translation-related condition and the control-related condition when they were preceded by homograph-unrelated trials (1,646 ms, *SE* = 132, and 1,628 ms, *SE* = 110, respectively), t_1 and $t_2 < 1$ (see Table 4).

Table 4. Mean reaction times in milliseconds (standard error into bracket) and percentage of errors for each condition in first and second trial (Experiment 2)

First Trial		
	Homograph – Unrelated	Control – Unrelated
Homograph – Unrelated	2090 (160)	1896 (160)
	32%	9%
Second Trial		
	Translation – Related	Control – Related
After Homograph – Unrelated	1646 (132)	1628 (110)
	24%	16%
After Control – Unrelated	1508 (144)	1451 (107)
	24%	18%

Accuracy. The ANOVA performed on the error data in the first trial showed that participants made more errors in the homograph-unrelated condition (33.12%, SE = 4.15) than in the control-unrelated condition (9.68%, SE = 2.25), $F_1(1, 15) = 54.12$, $MSE = 276.61$, $p < .001$, $F_2(1, 39) = 20.28$, $MSE = 436.25$, $p < .001$.

The analyses performed on the error data in the second trial showed that the interaction between the type of trial (translation-related condition vs. control-related condition) and the preceding first trial (homograph-unrelated vs. control-unrelated condition) was not significant, F_1 and $F_2 < 1$.

Comparisons between Experiments 1 and 2. As indicated above, the participants of both experiments were selected from the same pool and there were no differences between them in their L1 and L2 proficiency or in their demographic characteristics. In addition, the designs, materials and procedures of Experiments 1 and 2 were nearly identical, but varied in the time interval between the end of the first trial and the beginning of the second trial. We explored the time course of inhibitory processes in the second trial of the experimental block selecting two between trial time intervals: 500 ms (Experiment 1) and 750 ms (Experiment 2).

In each experimental block, the first trial was designed to explore the non-selective activation of the homographs two meanings. Longer RTs in the homograph-unrelated condition than in the control-unrelated condition were observed in both experiments. To show that the interference effect was similar in the two experiments we performed new analyses introducing the time interval (500 ms and 750 ms) as a between-subjects factor (within items factor) and the type of trial (homograph-unrelated vs. control-unrelated) as a within-subjects factor (within items factor). The outcome of this analysis showed a main effect of type of trial, $F_1(1, 30) = 18.74$, $MSE = 553327$, $p < .001$, $F_2(1, 75) = 13.46$, $MSE = 315196$, $p < .001$, that did not interact with the time interval, F_1 and $F_2 < 1$ (see Figure 1), indicating similar interference in both experiments.

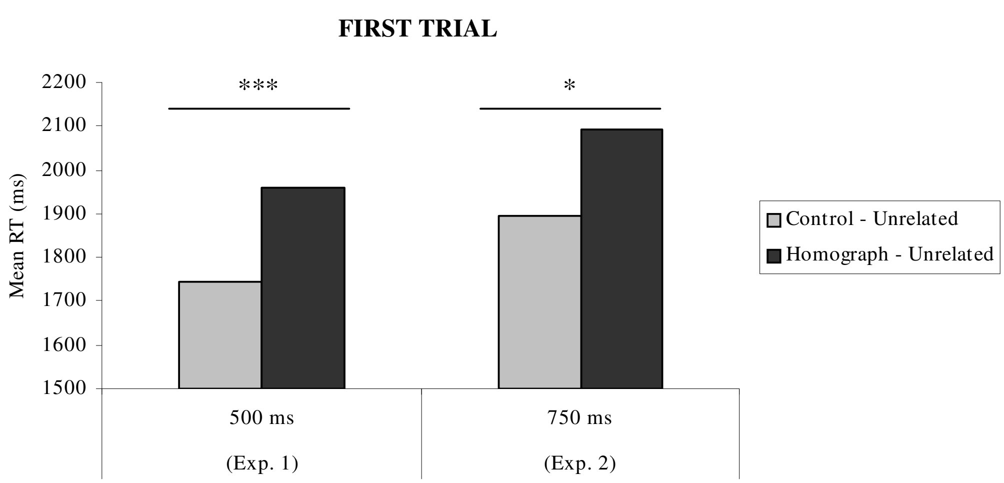

Figure 1. Mean reaction times in the first trial (control-unrelated condition and homograph-unrelated condition), in Experiments 1 and 2 (*$p < .05$, ***$p < .001$).

We further explored the time course of inhibitory processes by introducing the time interval (500 ms and 750 ms) in a new ANOVA with time interval as a between-subjects factor (within items factor) and type of trial (translation-related vs. control-related) and the preceding first trial (homograph-unrelated vs. control-unrelated) as within-subjects factors (within items factor). Although the Time interval x Type of Trial x Preceding first trial second-order interaction did not reach significance, $F_1(1, 30) = 1.93$, $MSE = 53479$, $p > .05$, $F_2(1, 67) = 2.20$, $MSE = 157499$, $p > .05$, further analyses showed that, after the homograph-unrelated trials, the interaction between Time interval x Type of Trial was significant by participants, $F_1(1, 30) = 7.23$, $p < .05$, and marginally by items, $F_2(1, 73) = 2.95$, $MSE = 254529$, $p = .09$, whereas it was not after the control-unrelated trials (F_1 and $F_2 < 1$). The interaction between Time Interval x Type of Trial after the homograph-unrelated trials, indicated that the longer RTs in the translation-related condition than in the control-related condition were observed only in the 500 ms time interval (281 ms of interference), while this difference was not significant in the 750 ms (18 ms of interference) (see Figure 2).

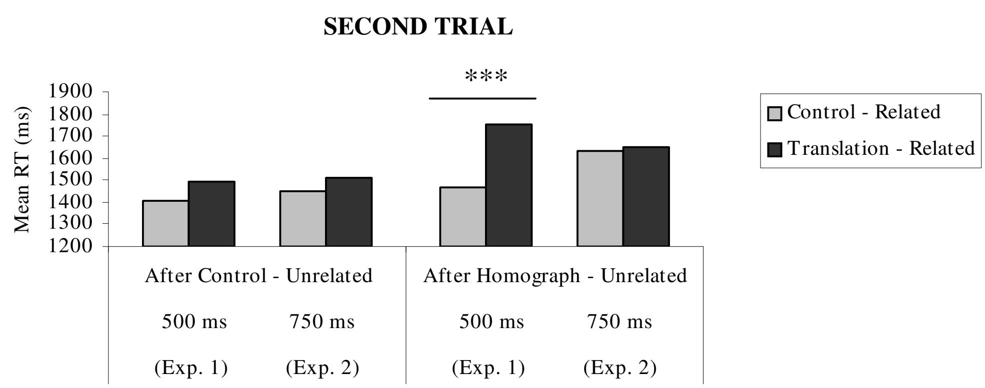

Figure 2. Mean reaction times in the second trial in the experimental conditions (control - related condition and translation - related condition) both after control – unrelated and homograph – unrelated conditions in the first trial, in Experiments 1 and 2 (***$p < .001$).

GENERAL DISCUSSION

Experiments 1 and 2 explored the involvement of inhibitory mechanisms in bilingual language processing and the time course of inhibition. We investigated these issues by using an adapted negative priming paradigm in which participants decided whether pairs of words were semantically related. The results of these experiments showed that the two meanings of an interlingual homograph were activated even though only the meaning in one language was relevant to perform the task. It took more time to respond to trials including homographs than to control trials. These results are in agreement with previous work supporting the non-selective view of bilingual language processing (De Groot et al., 2000). Furthermore, the activation of the Spanish non-target homograph meaning in this study occurred despite the fact that participants were not informed about the presence of interlingual homographs and only one language was required to perform the task.

One important finding of our experiments was the involvement of inhibitory processes to reduce between-language competition. According to the IC model (Green, 1998), the competition produced by the parallel activation of the bilinguals two languages when homographs are presented is resolved by the inhibition of the L1 irrelevant meaning of the homograph. Thus, the participants needed more time to respond when the Spanish meaning of the homograph became relevant during the second trial because they had to overcome this inhibition. Hence, in Experiment 1 participants were slower when responding to the translation-related relative to the control-related trials.

As mentioned, the inhibitory view of bilingual language selection has been widely tested throughout the use of the language switching paradigm. However, the asymmetrical switching cost has not been always replicated (Christoffels, Firk, & Schiller, 2007), and it is not yet well established whether language switching cost necessarily implies language suppression (Finkbeiner, Gollan, & Caramazza, 2006). In our opinion, a problem linked to use of the language switching tasks is that the procedure does not provide an index of between language activation. It is assumed that non-target representations are inhibited and that such inhibition is reactive to the degree of between-language competition, but there is not an independent empirical observation of language activation. In contrast, in the procedure that we used in Experiment 1 and 2, we have two independent indexes. First, the interference effect when bilinguals respond to interlingual homographs is an indicator of the activation of the two homograph meanings. Second, the delay in the bilinguals' responses to the translation of the irrelevant meaning of the homograph in the second trial is an index of the inhibition of the non-target meaning. An orthographic loci of the inhibitory effect observed in Experiment 1 seems to be not possible since the homograph was not presented in the second trial. Instead, the inhibitory effect might be located at the lexico/semantic level so participants took more time to retrieve the inhibited homograph meaning in the second trial.

In addition, we were interested in the time course of inhibition. Specifically, we focused on the interval between the time in which interference was produced by the non-selective activation of the two homograph meanings and the presentation of the inhibited irrelevant homograph-meaning. Results of Experiments 1 and 2 indicated that after 500 ms, the representation of the irrelevant meaning was inhibited, however, after 750 ms the inhibitory effect was not present. Thus, in Experiment 2, although we found interference in the first trial due to the non-selective activation of the two homograph meanings, we did not find differences between the translation-related condition and the control-related condition after responding to pairs with homographs. Hence, this seems to indicate that the effect of inhibition is very short lived.

This last conclusion contrast with recent results by Levy, McVeigh, Marful, and Anderson (2007) showing longer lasting effects of inhibition of L1 representations. In their study, English/Spanish bilinguals repeatedly named pictures in either their dominant language (English, e.g., *snake*) or their weaker language (Spanish, e.g., *serpiente*). Afterward, participants had to retrieve the English names (L1) of the items with the help of a rhyme cue (a word was presented and participants had to provide an English word that rhymed with a previously presented picture, e.g., *break_*). The results showed that retrieval of English words (L1) was poorer after repeatedly naming pictures in Spanish (retrieval-induced forgetting effect, RIF). This effect was explained by assuming that picture names in L1 competed for selection when naming pictures in the participants' L2 (Spanish) and, as a consequence, the phonology of the corresponding L1 words was inhibited. Thus, it was difficult to retrieve the inhibited L1 phonological representations when the rhyme cue was presented at test. An important feature of this inhibitory effect is that it endured well beyond the immediate context in which L1 and L2 representations competed for selection. In Levy et al.'s (2007) study, competition occurred in the naming phase while inhibition was observed in a subsequent final test. An open question is how the results observed in our Experiment 2 can be accommodated within the context of Levy et al.'s study. In our Experiment, the consequences of inhibiting the irrelevant homograph meaning were not observed after 750 ms, which suggest that inhibition is a transient effect, whereas the inhibitory effect observed after 20 min delay in Levy et al.'s study suggests that inhibition persists for a long period of time. One possible explanation might be related to methodological differences between these studies since the Levy et al. procedure involved many repetitions of the naming trials. It is possible that inhibiting the same representation in subsequent trials produces longer lasting effects. Further research should address this issue.

In conclusion, the present results provide evidence of cross-language activation in the presence of ambiguous words such as interlingual homographs, supporting the non-selective view in bilingual processing. In our experimental task, the activation of L1 representations produced interference between both languages, and inhibition was recruited to select the correct response. Our results also suggest that inhibition affects performance when the bilinguals have to respond to the inhibited representation in subsequent trials. Hence, inhibition seems to be a process that is recruited to resolve between-language competition, but this inhibition of the irrelevant representations seems to decay over time.

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CHAPTER VI

IMMERSION IN L2 AND EXPERTISE IN TRANSLATION DETERMINE LANGUAGE ACTIVATION AND LANGUAGE SELECTION[1]

We evaluated whether immersion in a second language (L2) environment and expertise in translation modulate bilingual language activation and the processes needed to select the language in use. To this aim, three different samples of bilinguals were tested: Two groups with no immersion in L2: Spanish-English bilinguals and Spanish-English translators, and a group of Spanish-English bilinguals immersed in their L2. The participants performed a semantic relatedness judgment task in which we used Spanish-English interlingual homographs as critical stimuli (e.g., pie meaning foot in Spanish). The non-immersed groups, Spanish-English bilinguals and translators, were slower to respond to homographs than to control words. This result suggests that participants experienced interference because of the non-selective activation of both languages. No interference effect was found for the immersion group. Interestingly, after responding to homographs, only the Spanish-English bilinguals without L2 immersion slowed their responses to the English translation of the Spanish homograph meaning. This result indicates that participants needed more time to respond to the translation because they had to overcome the inhibition of the irrelevant homograph meaning. The different pattern of results found for the three groups of bilinguals reflects differences in the activation and selection of their languages according to their previous experience with them.

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[1] This paper was co-authored by Pedro Macizo and Teresa Bajo.

INTRODUCTION

Recent research on bilingualism have tried to answer the questions of how languages are represented in the bilingual mind and how bilinguals manage to select the language they need (see Kroll & Tokowicz, 2005; for a review). Many studies have shown that the two languages of the bilingual are active even in situations where the bilingual needs to use only one (non-selective activation, see Dijkstra, 2005; for a review). The parallel activation of the two languages provides opportunities for between-language interactions that may produce between-language competition when the bilinguals have to select the appropriate lexical entries in only one language. The presence of between-language competition introduces the need for a control mechanism that regulates the activation of the non-target language in order to correctly select the intended one. Although there is no agreement about the mechanism that allows language selection, the available evidence suggests that inhibitory control may act to suppress the activation of the competing alternatives in the non-intended language to allow the accurate selection of the appropriate lexical entries in the intended one (see Kroll, Bobb, Misra, & Guo, 2008; Meuter, 2005; for reviews).

However, the non-selective activation of the two languages of the bilingual is not always observed and previous research has shown that it might depend on several aspects (Christoffels, De Groot, & Kroll, 2006; Ibáñez, Macizo, & Bajo, 2010; Linck, Kroll, & Sunderman, 2009). Thus, the degree of between-language competition depends on factors, such as language proficiency and dominance (Costa & Santesteban, 2004; Elston-Güttler, Paulmann, & Kotz, 2005), the cognitive resources available to the bilingual (Ibáñez et al., 2010; Macizo & Bajo, 2006), the context in which the bilinguals are immersed or their particular experience with the language (see Kroll, Bobb, & Wodniecka, 2006; for a review). The aim of the present work is to explore two additional factors that might modulate language activation and also control processes in language selection: immersion in a second language (L2) environment and expertise in translation.

Immersion in L2 context

Overall, between-language competition is easily observed in bilinguals who are continuously exposed to their native language (L1) when they are evaluated in their weaker language (L2). In this situation, it is reasonable to expect competition from the non-intended language (L1), first because it is the dominant language, and second because the environment favours its activation (an L1 speaking context). The existing literature on bilingual processing provides wide evidence of L1 activation in bilinguals immersed in L1 that perform L2 language production (Kroll et al., 2006; Marian & Spivey, 2003) and L2 language comprehension (Dijkstra, 2005; Dijkstra & Van Heuven, 2002; Macizo, Bajo, & Martín, 2010). However, L2 immersion might reduce between-language competition. The distinctive feature of an immersion environment is that individuals are visually and auditorily surrounded by their L2. In this situation the influence of L1 when performing an L2 linguistic task may be reduced.

Although little research has been done about the effect of L2 immersion, previous studies on this issue suggest that the immersion in an L2 context leads to a change in the way in which both L2 and L1 are processed. Link et al. (2009) compared the performance of two groups of native English speakers who were learning a second language (Spanish) in two different learning contexts. One group was studying Spanish in a classroom context and the other group was immersed in a Spanish environment during a semester studying abroad. The participants performed a translation recognition task and a verbal fluency task in L1 and L2. In the translation recognition task, participants were presented word pairs (an L2 word and an L1 word, e.g., *cara-face*) and they had to decide whether the two words were a correct translation pair. Among the pairs to be rejected there were pairs similar in lexical form to the Spanish word (e.g., *cara-card*), similar to the English translation (e.g., *cara-fact*), or related in meaning to the Spanish word (e.g., *cara-head*). Classroom learners showed interference in all three conditions, whereas the immersed group did not show lexical form interference. In addition, the results of the verbal fluency task showed that the immersed learners group produced a larger number of examples in Spanish and, critically, they produced significantly fewer examples in English, their L1. The pattern of results obtained by the authors in comprehension and production suggests that activation of L1 and L1 to L2 competition was weaker in participants immersed in L2 context.

Expertise in translation

The role of expertise in translation has been previously explored in relation to the linguistic and cognitive processes involved in translation and interpreting tasks (Christoffels & De Groot, 2005; Christoffels et al., 2006; Ibáñez et al., 2010; Macizo & Bajo, 2006). When translators perform translation tasks they have to comprehend and reformulate a given message expressed in one language into another language. Despite differences among the existing varieties of translation tasks, the main characteristic of the translation performance is that the translator has not only to understand and reformulate a message from one language to another, but also she or he has to maintain active their two languages and to switch continually between them. Therefore, translators have to manage the activation of two languages and be continuously coping with the interference coming from the parallel activation of the two languages in the translation task. Although inhibitory control has been suggested as the way bilinguals select the required language (e.g. Green, 1998), this mechanism does not seem appropriate for performing translation tasks since in these tasks one language has to be active to comprehend the input while the other has to be also active in order to simultaneously produce the output.

Although little research has been done about expertise in translation as a modulating factor on the way bilinguals regulate language activation, the results obtained by Ibáñez et al. (2010) suggest that bilinguals may differ in the way they negotiate their two (or more) languages. In their study, Ibáñez et al. asked professional translators to read and understand sentences, and repeat them in the language of presentation (Spanish: L1 or

English: L2). To explore the non-selective activation of both languages they introduced cognate words (e.g., zebra/cebra, in English/Spanish, respectively) in the sentences, taking the possible cognate effect as an index of between-language activation. In addition, in order to explore the nature of the lexical selection mechanism, they adapted the language switching paradigm (e.g., Meuter & Allport, 1999) to a sentence reading task. Thus, the sentences were presented in Spanish (L1) or English (L2) in an unpredictable manner. The authors took the asymmetrical switching cost (larger switching cost to the dominant L1 than to the less dominant L2) as an index of inhibitory control. The results showed that translators were faster processing cognate words as compared to control words while they did not show asymmetrical language switching cost. These two results suggest that translators kept active their two languages without inhibiting any of them.

The experiment we report in the present work aimed to explore whether immersion in a second language environment and expertise in professional translation are factors that modulate not only between-language activation but also the processes involved in language selection. To this aim we tested three different bilingual populations: Two groups with no immersion in L2: Spanish-English bilinguals and Spanish-English translators, and a group of Spanish-English bilinguals immersed in their L2.

We used the experimental task previously used in our laboratory with interlingual homographs as critical stimuli (Macizo et al., 2010; Martín, Macizo, & Bajo, 2010), since it has been shown to capture both the interference effect due to the non-selective language activation and the inhibitory effect resulting from target selection. In this task, pairs of English words were presented and participants decided whether or not they were semantically related. The word pairs were presented in English (the participants' L2). The task was carried out in blocks of two trials. The first trial aimed to capture L1 activation when bilinguals processed L2 words, while the second trial aimed to capture the inhibition needed to overcome interference. In the first trial, pairs of unrelated English words were presented, so the participants correct response was "no". In the critical condition, an interlingual homograph (e.g., "*pie*", meaning "foot" in Spanish) was presented along with another word that was unrelated to the English meaning of the homograph but related to the Spanish meaning (e.g., "*pie-toe*"). When a pair like "*pie-toe*" was presented, participants had to respond "no" since both words were unrelated in English. This condition was compared to a control condition in which a matched non-homograph word along with an unrelated English word was presented (e.g., "*log-toe*"). If the irrelevant homograph meaning was activated, participants would take longer to respond in the homograph-unrelated condition than in the control-unrelated condition, showing the non-selective activation of their two languages.

In the second trial, pairs of English related words were presented, so that the participant's correct response was "yes". In the critical condition, the English translation of the non-target homograph meaning (e.g., "*foot*") was presented along with a related word (e.g., "*hand*"). This condition was compared to a control-related condition in which a matched related word was presented along with an English word (e.g., "*finger-hand*"). Longer response times in the translation-related condition as compared to the control-related condition when preceded by the homograph-unrelated condition (e.g., "*foot-hand*" preceded by "*pie-toe*") would reflect that the L1 irrelevant homograph meaning was inhibited in the first trial.

As we mentioned before, previous studies suggest that the influence of L1 might be less evident for people immersed in L2, because of the increment in usage of their L2 (Link et al., 2009), consequently, these immersed participants might not be affected by their L1, and therefore they might not show interference in the first trial. Regarding expertise in translation, since translation requires continuous activation of the two languages but not inhibition of any of them, translators might show between-language competition in the first trial without sign of inhibition in the second trial.

METHOD

***Participants*.** Three groups of Spanish-English bilinguals participated in the experiment. One group consisted of sixteen Spanish/English bilinguals (9 women, 7 men) from the English department at the University of Granada (Spain). This group served as a control for further comparisons of interest with the other bilingual groups. The second group consisted of sixteen Spanish/English bilinguals (9 women, 7 men) from Penn State University (USA) who was immersed in an English language environment (M = 2.90 years of L2 immersion). The third group consisted of sixteen Spanish/English bilinguals (11 women, 5 men) experienced in professional translation for more than two years (M = 6.37 years of experience). All the participants volunteered to participate in this experiment and they were paid for their participation. The bilinguals were native speakers of Spanish (L1) and fluent in English (L2). Before performing the experiment, all groups of participants completed a self-rating questionnaire previously used in our lab (Macizo & Bajo, 2006; Macizo et al., 2010; Martín et al., 2010) in which they had to rate their speech fluency, speech comprehension, writing and reading skills. The questionnaire was also intended to obtain information about their language history and experience in L1 and L2. Participants across the three groups did not differ in their L1 and L2 proficiency (all p values > .05). The participants' characteristics are reported in Table 1.

Table 1. Characteristics of participants in the study

	Bilinguals	L2 Immersed bilinguals	Translators
Age (years)	23.59 (2.65)	30.81 (6.24)	29.68 (7.11)
Age starting L2 learning	7.88 (3.24)	9.71 (2.92)	9.21 (1.96)
Living in L2 speaking countries (months)	14.00 (7.05)	34.91 (29.43)	13.00 (5.45)
Experience in professional translation (years)	0.00 (0.00)	0.00 (0.00)	6.37 (5.20)
Language Proficiency Questionnaire			
L1 Speech fluency	9.56 (0.81)	9.75 (0.57)	9.91 (0.24)
L1 Speech comprehension	9.69 (0.60)	9.93 (0.25)	9.81 (0.33)
L1 Writing proficiency	9.44 (0.81)	9.62 (0.62)	9.75 (0.38)
L1 Reading proficiency	9.50 (0.89)	9.75 (0.57)	9.91 (0.24)
L2 Speech fluency	7.56 (1.15)	7.20 (1.97)	7.91 (0.67)
L2 Speech comprehension	7.88 (1.36)	7.63 (1.85)	8.25 (0.64)
L2 Writing proficiency	7.44 (1.26)	7.03 (2.00)	7.83 (0.80)
L2 Reading proficiency	7.81 (1.28)	7.90 (1.00)	8.41 (0.77)

Note. The self-report ratings in L1 (Spanish) and L2 (English) ranged from 1 to 10 where 1 was not proficient and 10 was very proficient. Standard deviations are reported into brackets.

Design and Materials. The design and materials used in this experiment were the same as those used in Macizo et al. (2010) and Martín et al. (2010). Blocks of two trials were presented, each trial consisting of English word pairs. The two words in the first trial were unrelated while word pairs in the second trial were related. Two conditions were established in the first trial (see Table 2): (a) *Homograph-unrelated condition*: A Spanish-English interlingual homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, (b) *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word which was unrelated to the other word in the pair. Another two conditions were established in the second trial: (c) *Translation-related condition*: The English translation of the Spanish homograph meaning was presented along with a related English word, (d) *Control-related condition*: The English translation word was replaced by a control matched word. Consequently, a within-subjects factorial design was employed in which each participant was exposed to all experimental conditions. The presence of homographs was manipulated in the first trial, and the presence of English translation of Spanish homograph meanings was manipulated in the second trial. In addition, the condition that preceded the second trial was manipulated so that, conditions (c) and (d) occurred after either condition (a) or (b).

Table 2. Sample word stimuli used in the experiments

Condition	Example 1	Example 2
First Trial		
Homograph – Unrelated	pie toe	red tennis
Control – Unrelated	log toe	dark tennis
Second Trial		
Translation – Related	foot hand	net ball
Control – Related	finger hand	hit ball

Note. *Homograph-unrelated condition*: A Spanish-English interlingual homograph was presented along with a word unrelated to the English homograph meaning but semantically associated to the Spanish homograph meaning, *Control-unrelated condition*: The homograph was replaced by a non-homograph matched word, *Translation-related condition*: The English translation of the Spanish homograph meaning was presented along with a related English word, *Control-related condition*: The English translation word was replaced by a control matched word. The translation-related condition and control-related condition were both preceded by either homograph-unrelated condition or control-unrelated condition in the first trial.

Forty Spanish-English interlingual homographs were selected from NTC Spanish/English Cognates Dictionary (Nash, 1997) with identical orthography in Spanish (Alameda & Cuetos, 1995) and English (Brysbaert & New, 2009) but different meaning across languages. The mean lexical frequency of the English homograph meaning was matched in lexical frequency, 395 (*SD* = 1035) (Brysbaert & New, based on one-million count) with the Spanish meaning of the homographs, 410 (*SD* = 1658) (Alameda & Cuetos, based on two-million count but computed here as one-million count), $t < 1$. The *t*-test comparison after transforming these frequencies to their natural log showed no differences between the English meaning of the homographs (1.47, *SD* = 0.97) and the Spanish meaning of the homographs (1.12, *SD* = 1.10), $t(39) = 1.43$, $p > .05$. For each homograph an English word was selected so that it was unrelated to the English homograph meaning but it was semantically associated to the Spanish homograph meaning (homograph-unrelated condition). The mean forward associative strength between the Spanish homograph meaning (cue word) and its associated word (target word) was 0.17 (*SD* = 0.15) (Kiss, Armstrong, Milroy, & Piper, 1973; Nelson, McEvoy, & Schreiber, 1998). The forward associative strength or what is also called the cue-to-target strength gives the proportion of participants in a free association task who produce the target in the presence of the cue. A new set of forty non-homographs were selected for the control-unrelated condition. Homographs and control words were matched for their lexical and semantic characteristics obtained from Wilson's database (1988) and from Brysbaert & New's database. The mean number of letters for homographs and control words was 4.15 (*SD* = 1.03) and 4.15 (*SD* = 0.98), respectively. The mean frequency for homographs and control words was 395 (*SD* = 1,035) and 1,712 (*SD* = 7,182), respectively. The mean concreteness value for homographs and control words was 429 (*SD* = 154) and 447 (*SD* = 146), respectively. The mean value of familiarity for homographs and control words was 549 (*SD* = 52) and 554 (*SD* = 47), respectively. The mean meaningfulness value for homographs and control words was 410 (*SD* = 69) and 434 (*SD* = 74), respectively.

The forty English translations of the Spanish homograph meanings were used along with a new set of forty associated words for the translation-related condition in the second trial. In addition, the control-related condition was constructed by substituting the English translation word for a new matched control. The English translation word and the control word were matched for length (4.60, *SD* = 1.26, and 4.95, *SD* = 1.71, respectively), mean frequency (289, *SD* = 842, and 357, *SD* = 1,537, respectively), mean concreteness values (442, *SD* = 125, and 488, *SD* = 110, respectively), mean familiarity values (551, *SD* = 41, and 562, *SD* = 33, respectively), and mean meaningfulness values (419, *SD* = 64, and 446, *SD* = 35, respectively). The mean forward associative strength for the translation-related pairs and the control-related pairs was equated (0.17, *SD* = 0.16, and 0.18, *SD* = 0.24, respectively), $t < 1$. The mean backward associative strength for the translation-related pairs and the control-related pairs was equated also (0.11, *SD* = 0.18, and 0.13, *SD* = 0.19, respectively), $t < 1$.

Four stimulus lists were created in order to counterbalance the items over conditions. Each list consisted of 40 blocks of two trials. In 20 blocks, the first trial was assigned to the homograph-unrelated condition whereas the first trial of another 20 blocks was assigned to the control-unrelated condition. Ten homograph-unrelated trials and ten control-unrelated trials were followed by translation-related trials; the remaining trials were followed by control-related trials. The experimental conditions were counterbalanced across lists. Twenty filler blocks were also added to each list to avoid the predictable sequence of “no”-“yes” responses. The first trial of these blocks was composed by new pairs of related words and the second trial comprised pairs of unrelated words. Experimental and filler blocks were randomized within lists; all words appeared only once on the list and each participant saw only one of the four lists. A short practice list preceded the experimental lists. This list was constructed from a different set of words arranged in 12 two-trial blocks with the same proportion of related and unrelated words pairs.

Note that the design and material were constructed so that the critical comparisons in the experiment are within trials involving the same type of yes/no response. In the first trial the critical comparison between homograph-unrelated condition and control-unrelated condition was associated to "no" responses. In the second trial, the critical comparison between translation-related condition and control-related condition was associated to "yes" responses. Moreover, the possible effect of changing responses between trials was kept constant so that the "after homograph-unrelated" condition and the "after control-unrelated" condition always involved the same change of response relative to the previous trial (see Macizo et al., 2010).

Procedure. The experiment was controlled by a Genuine-Intel compatible 2993 MHz PC using E-prime experimental software, 1.1 version (Schneider, Eschman, & Zuccolotto, 2002). Participants were tested individually. Stimuli were presented in lower-case black letters (Courier New font, 18 point size) on a white background. The participants were seated approximately 60 cm from the computer screen. At this viewing distance, one character subtended a vertical visual angle of 0.48 degrees and a horizontal visual angle of 0.67 degrees. Blocks of two trials were presented. The first trial began with a fixation point consisting of two crosses displayed in the same line at the center of the screen for 600 ms. Afterwards, the word pair for the first trial appeared in the positions where the fixation crosses were located. The homographs (homograph-unrelated condition) and their matched control words (control-unrelated condition) appeared on the left side whereas the unrelated words were displayed on the right side. This word pair remained on the screen until a response was made. Five-hundred milliseconds after the participant's response to the first trial, the word pair for the second trial was presented. As in the first trial, these words remained on the screen until the participant's response. The English translation of the Spanish homograph meanings (translation-related condition) and their control matched words (control-related condition) were displayed on the left side whereas related words appeared on the right side. The participants were informed that they had to decide whether English word pairs were related or unrelated by pressing the "m" and "z" keys on the computer keyboard for related and unrelated responses, respectively. Participants were not informed about the presence of homographs across languages.

RESULTS

Two analyses of variance (ANOVAs) were performed on RT and accuracy in the first trial and in the second trial. For the ANOVA performed on the first trial we considered Type of trial (homograph-unrelated, control-unrelated) as within-subjects factor and Group (Spanish-English control bilinguals, L2 immersed Spanish-English bilinguals, and Spanish-English translators) as between-subjects factor. For the ANOVAs performed on the second trial we considered Type of trial (translation-related, control-related) and Preceding trial (homograph-unrelated, control-unrelated) as within-subjects factors, and Group (Spanish-English control bilinguals, L2 immersed Spanish-English bilinguals, and Spanish-English translators) as between-subjects factor.

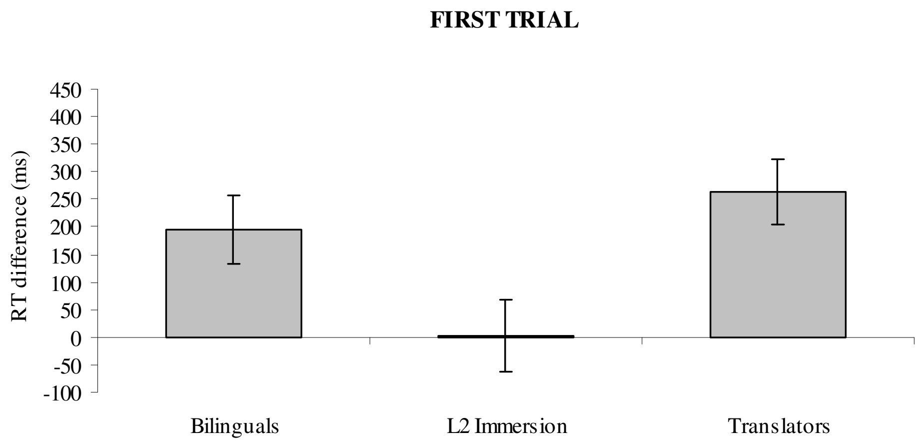
Incorrect responses (17.19% of the data for the Spanish-English control bilinguals; 18.59% of the data for the L2 immersed Spanish-English bilinguals; and 19.37% of the data for the translators) and the reaction times (RTs) exceeding a criterion of 2.5 *SD* from the participant's mean (3.45% of the data for the L2 immersed Spanish-English bilinguals; 2.72% of the data for the Spanish-English control bilinguals; and 2.81% of the data for the translators) were excluded from the latency analysis.

The analyses performed on the first trial showed that the Type of trial x Group was significant in the RT analysis, $F(2, 45) = 4.80$, $p < .05$, but not for the percentage of errors, $F(2, 45) = 1.23$, $p > .05$. In addition, the analyses performed on the second trial showed that the Type of trial x Group was also significant for both RTs, $F(2, 45) = 3.63$, $p < .05$, and for the percentage of errors, $F(2, 45) = 3.85$, $p < .05$. In order to qualify these interactions, we evaluated the effect of L2 immersion and experience in translation by comparing L2 immersed Spanish-English bilinguals and professional translators with the group of Spanish-English control bilinguals, respectively.

L2 immersion: L2 immersed Spanish-English bilinguals vs. Spanish-English control bilinguals

The analyses performed on the first trial showed that the Type of trial x Group interaction was significant for RTs, $F(1, 30) = 4.59$, $p < .05$, but not for the percentage of errors, $F(1, 30) = 1.01$, $p > .05$. The Spanish-English control bilinguals responded more slowly to homographs (2,002 ms, $SE = 125$) than to control trials (1,808 ms, $SE = 100$), $F(1, 15) = 9.73$, $p < .05$. However, no significant differences were found between homograph trials and control trials for the L2 immersed Spanish-English bilinguals (2,121 ms, $SE = 218$ and 2,118 ms, $SE = 204$, respectively), $F < 1$.

The analyses performed on the second trial showed that the interaction between Type of trial and Group was significant for both RTs, $F(1, 30) = 5.45$, $p < .05$, and percentages of errors, $F(1, 30) = 5.45$, $p < .05$. In the Spanish-English bilingual control group the interaction between Type of trial and Preceding trial was significant, for RTs, $F(1, 15) = 5.68$, $p < .05$, but not for errors, $F < 1$. Further comparisons showed that there were no differences between the translation-related condition and the control-related condition when they were preceded by control-unrelated trials (1,505 ms, $SE = 77$, and 1,427 ms, $SE = 83$, respectively), $F(1, 15) = 1.95$, $p > .05$. However, significant differences were found between the translation-related condition and the control-related condition when they were preceded by homograph-unrelated trials (1,729 ms, $SE = 99$, and 1,403 ms, $SE = 46$, respectively), $F(1, 15) = 17.17$, $p < .05$. The results for the L2 immersed Spanish-English bilinguals group indicated that the interaction between Type of trial and Preceding trial was not significant, $F < 1$ (see Figure 1).



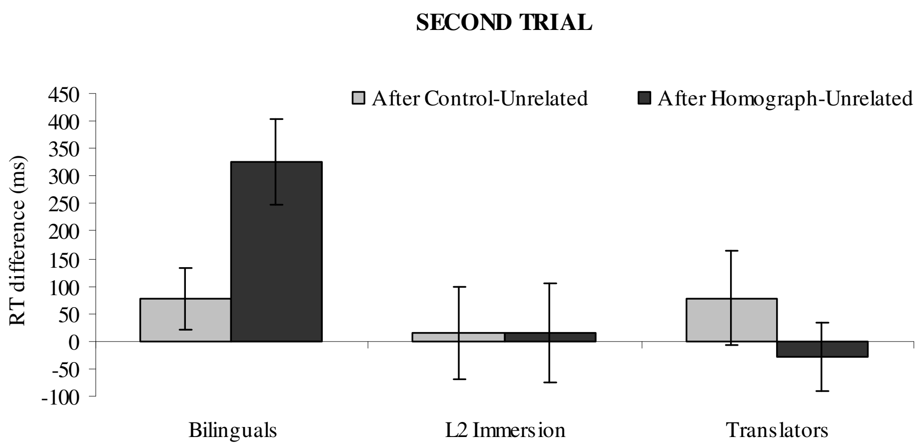


Figure 1. Upper graph: Interference effect in the first trial (homograph-unrelated condition minus control-unrelated condition) on the mean reaction times (RT, in milliseconds) for the three groups of participants. Lower graph: Inhibitory effect in the second trial (mean RT difference, in milliseconds, between translation-related condition and control-related condition) as a function of the preceding trial (after control-unrelated condition and homograph-unrelated condition) for the three groups of participants. Error bars represent standard error.

Experience in translation: Translators vs. Spanish-English control bilinguals

The analyses performed on the first trial showed that the Type of trial x Group interaction was not significant for RTs, $F < 1$. Similarly, this interaction was not significant in the analysis performed on the percentage of errors, $F(1, 30) = 2.47$, $p > .05$.

The analyses performed on the second trial showed that the Type of trial x Preceding trial x Group second-order interaction was significant for RTs, $F(1, 30) = 5.62$, $p < .05$, but not for errors, $F < 1$. To examine this interaction, we performed separate ANOVAs for each group of participants. As we indicated before, Spanish-English control bilinguals presented the effect of Type of trial only after homograph-unrelated trials. However, the results for the translators group showed that neither the main effects nor the interaction between Type of trial x Preceding trial were significant (*p*s > .05) (see Table 3).

Table 3. Mean reaction times in milliseconds (standard error into bracket) and percentage of errors for each condition in first and second trial for the three groups of participants in the study

First Trial	Homograph-Unrelated			Control-Unrelated		
	Bilinguals	Immersed	Translators	Bilinguals	Immersed	Translators
	2002 (125)	2121 (218)	1981 (161)	1808 (100)	2118 (204)	1725 (136)
	30% (2.83)	30% (3.47)	35% (3.70)	8% (3.05)	4% (1.28)	6% (1.49)
Second Trial	Translation-Related			Control-Related		
	Bilinguals	Immersed	Translators	Bilinguals	Immersed	Translators
After Homograph-Unrelated	1729 (99)	1702 (114)	1446 (86)	1403 (46)	1688 (139)	1474 (64)
	14% (2.40)	23% (3.84)	7% (1.57)	16% (3.63)	11% (2.91)	7% (1.58)
After Control-Unrelated	1505 (77)	1676 (99)	1441 (78)	1427 (83)	1660 (138)	1363 (72)
	15% (3.15)	24% (3.28)	11% (2.35)	13% (3.01)	19% (3.47)	9% (2.10)

DISCUSSION

The present work aimed to investigate whether immersion in an L2 environment and expertise in translation are modulating factors of language activation and control processes involved in language selection. We investigated these issues by testing three groups of Spanish-English bilinguals differing in their language environment (immersion in an L2 context or in an L1 context) and their experience in professional translation. In the study we used an adapted negative priming paradigm in which participants decided whether pairs of English words were semantically related. Results showed different pattern of activation and inhibition for the three groups indicating that immersion and experience in translation modified the way in which the two languages are negotiated. The role of these two factors is discussed next.

Immersion in L2 context

In order to specify the effect of L2 immersion, we compared performance of the Spanish-English control bilinguals group with that of the L2 immersed Spanish-English bilinguals group. The Spanish-English control bilinguals were slower responding to homograph trials than to control trials, indicating that they experienced interference because of the activation of the non-target L1 homograph meaning. Furthermore, after responding to homographs, the Spanish-English control bilinguals slowed their responses when the irrelevant homograph meaning became relevant in the second trial. By contrast, the L2 immersed Spanish-English bilinguals showed no sign of L1 activation since they responded equally fast to homograph and to control trials. As no between-language competition was observed in the first trial for this group of participants, no inhibitory effect was observed in the second trial and no differences were found either after homographs or after control trials.

The results showed that language activation depended on the language immersion context of the participants. Although the task required only one language (the participants' L2, English), the presence of interlingual homograph effects in the Spanish-English control bilinguals indicated that both meanings of the homograph (Spanish and English) were activated. In addition, results of the second trial showed that to correctly select the target meaning, the participants inhibited the Spanish homograph meaning to reduce between-language competition. Thus, when the Spanish meaning of the homograph became relevant in the second trial, the participants slowed their responses indicating that they needed time to overcome this inhibition.

The pattern of results obtained for the Spanish-English bilinguals control group exactly replicates that obtained by Macizo et al. (2010). They are also in agreement with the existing literature showing that L1 activation is easily observed when bilinguals are working in their less dominant L2 while immersed in an L1 context (Dijkstra, 2005; Kroll et al., 2006). The parallel activation of both languages makes it necessary to control activation of the non-target and dominant language. Thus, the dominant language may need to be suppressed to allow the selection of the intended one (Green 1998; Macizo et al., 2010; Martín et al., 2010).

However, in our study the L2 immersed Spanish-English bilinguals did not show between-language competition. When between-language activation is not observed and no interference is produced, there is no need for inhibitory control to take place. This result suggests that immersion in an L2 context might reduce between-language competition modulating the activation of the L1. When bilinguals are exposed to an L2 immersion context, they have to constantly deal with the interference of their dominant L1 in order to understand and produce the L2, at least at the first stages of the immersion experience. In this sense, previous studies about the effect of L2 immersion suggest that this factor can modulate L2 and L1 processing (Link et al., 2009). In their study, Link et al. showed that, after a brief L2 immersion exposure, L1 activation and between-language competition were reduced in L2 immersed learners as compared to the classroom learners. Moreover, the authors suggested that, in an L2 immersion context, the L1 might be globally inhibited reducing its modulating role in L2 lexical processing. According to this explanation, at the beginning of the immersion experience, bilinguals exert inhibitory control over their dominant L1 in order to understand and produce the L2 (Green, 1998; Link et al., 2009). Thus, during immersion in L2, bilinguals would inhibit frequently their L1 to reduce between-language competition. This continuous inhibition of L1 during long exposures to L2 environment might have long-term consequences for the easiness with which L1 is accessed. For example, Levy, McVeigh, Marful, and Anderson (2007) showed that repeated practice in L2 picture naming was associated to the inhibition of L1 representations, so that in a delayed phonological memory test access to the corresponding L1 words was impaired.

Although this explanation is consistent with our results and with the explanation provided by Link et al., (2009), it could be argued that the lack of interference from the two meanings of the interlexical homographs in our immersed group could also be explained by theories stressing the relative frequency of use of the bilingual two languages (e.g., the "weaker links" account; Gollan, Montoya, Cera, & Sandoval, 2008; Gollan, Montoya, Fennema-Notestine, & Morris, 2005). One difference between our study and the study by Link et al. is the degree of exposure to L2. Our immersed group was composed of fluent bilinguals (not learners) that had been immersed in a L2 context for a longer period of time than those in Link et al's study. It could be argued that the non-target language (in our study, the participants' L1) can be less active for people immersed in their L2 because they have increased usage in their L2. That is, the relative frequency of use of L1 and L2 might have changed so that L2 is now the more frequent language. According to relative frequency of use theory, because bilinguals use two languages, the frequency of use of words in each language is smaller relative to the frequency of use for monolinguals. As a consequence, bilinguals would have faster access to the more practiced lexical representations. In the case of the L2 immersed bilinguals, the increase in the frequency of use of L2 relative to L1 might make L1 representations less accessible. However, the "weaker links" account would predict that the less accessibility of the L1 observed for the bilinguals while immersed in their L2, should be reduced once the bilinguals return to an L1 context. Linck et al. evaluated this hypothesis by retesting a subset of the immersed learners six months after they returned to the L1 context. The results of the verbal fluency task at retest showed a rebound for their L1 performance, whereas they remained insensitive to lexical form interference in the translation recognition task. The authors concluded that the overall pattern of results found at retest is better explained according to an inhibitory account.

Expertise in translation

In the present study, we also were interested in expertise in translation as a modulating factor of the way in which bilinguals regulate their languages. To this aim, we compared Spanish-English bilinguals without training in translation with Spanish-English professional translators. The results showed that both groups of participants activated the non-intended language (L1) because they took longer to respond to homographs presented along with words related to the irrelevant L1 meaning of the homograph. Although we observed the interference effect in the first trial for both groups, the translators group showed no inhibitory effect in the second trial since no differences were found between control and translation trials.

Given that translators showed between-language activation but no inhibitory effect, it is worth questioning how they selected the target language to perform the task. Most bilingual models of language processing propose that language selection in bilinguals requires inhibition of the candidates in the non-target language (Dijkstra & Van Heuven, 1998; Green, 1998). Nevertheless, evidence from recent studies suggests that translators may not be using inhibitory processes to control the parallel activation of their two languages (Ibáñez et al., 2010). The results of this study suggest that the translators keep active their two languages without inhibiting any of them. Our findings are in agreement with this result.

It might be argued that lexical selection entails inhibitory control depending on the proficiency level reached in any pair of languages (Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006). According to Costa and Santesteban, an increase in L2 proficiency would lead to a change in the type of selection mechanisms used to select the intended language in such a way that low proficient bilinguals would use an inhibitory mechanism to control lexical selection while high proficient bilinguals would use a language-specific selection mechanism that allows them to focus only on one language. However, the differences found in our study between untrained bilinguals and translators cannot be explained in terms of proficiency differences since both groups were equated in L1 and L2 proficiency measures.

It has been suggested that the experience in complex tasks that imply high demands on cognitive control, such as interpreting and translation, enhances cognitive abilities beyond the abilities showed by normal bilinguals (Christoffels, De Groot, & Waldorp, 2003; Macizo & Bajo, 2006; Padilla, Bajo, & Macizo, 2005). Hence, it is possible that the extensive experience in translation makes translators to develop greater efficiency in L2 processing than ordinary bilinguals. Thus, translators might regulate the concurrent activation of their two languages by alternative non-inhibitory control mechanisms such as efficient access to semantic information to avoid phonological interference (Padilla et al., 2005) or an increased cognitive flexibility to manage the simultaneous activation of the two languages (Yudes, Bajo, & Macizo, submitted).

To conclude, this study shows that immersion in an L2 context and expertise in translation can modulate the way in which both languages of the bilingual are processed.

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CHAPTER VII

GENERAL DISCUSSION

The main aim of the studies included in the present thesis was to provide empirical evidence of the presence of inhibitory processes in language selection and to investigate how some important factors in bilingual processing modulate lexical access in bilinguals. In this final chapter, we present a general overview and discussion of the main empirical findings which will be organized around the main research topics included in the present dissertation. A brief outline of some future research questions is included at the end of the chapter.

The studies included in this dissertation aimed mainly to investigate the involvement of inhibitory processes in language selection during comprehension. With this purpose in mind we introduced several tasks in which Spanish-English bilinguals processed interlexical homographs. Along the empirical chapters of the present thesis, we tried to answer specific question regarding inhibition and language selection.

In Chapter III, we aimed to gather evidence of the presence of inhibitory processes while Spanish-English bilinguals selected the English meaning of interlexical homographs. In Chapter IV, we wanted to replicate the findings in Chapter III behaviourally and to explore the cortical activity associated to the cross-language effects observed in Chapter III. In Chapter V we explored whether the inhibitory processes involved in language selection extend in time. And finally, in Chapter VI we investigated whether immersion in a second language environment and expertise in professional translation modulate between-language activation and the control processes involved in language selection.

INHIBITORY PROCESSES IN LANGUAGE SELECTION

A large number of studies on bilingualism, using both behavioural and electrophysiological measures, has consistently shown that lexical entries in the L1 are activated while bilinguals are processing in the L2 (De Bruijn, Dijkstra, Chwilla, & Schriefers, 2001; De Groot, Delmaar, & Lupker, 2000; Dijkstra, 2005; Kerkhofs, Dijkstra, Chwilla, & de Bruijn, 2006; Kroll, Bobb, & Wodniecka, 2006; Marian & Spivey, 2003; Paulmann, Elston-Güttler, Gunter, & Kotz, 2006; Thierry & Wu, 2007). Given that the cross-language activation gives the opportunity for cross-language interactions and might produce between-language competition, an important research question on the field has been how lexical selection is achieved in bilinguals under these circumstances.

One strategy to raise this issue has been to use interlexical homographs.

However, mixed results have been found for homograph processing. Whereas some studies have found homograph effects (i.e., delayed responses to interlexical homographs related to control words; De Groot, Delmaar, & Lupker, 2000; Jared & Szucs, 2002), other studies have yielded facilitation effects depending on task demands, stimuli characteristics and language domain (Dijkstra, De Bruijn, Schriefers, & Ten Brinke, 2000; Dijkstra, Timmermans, & Schriefers, 2000; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998). Therefore, it will be useful to have a paradigm in which between language activation is found and them to explore modulating factors that might determine the presence of coactivation across bilinguals' languages.

On the other hand, although there is no agreement about the nature of the control mechanism involved in language selection, a recent body of evidence suggests the presence of inhibitory processes in language selection (Kroll, Bobb, Misra, & Guo, 2008; for a review). However, most of the empirical evidence supporting inhibitory processes in bilingual processing comes from the language production domain (Costa & Santesteban, 2004; Meuter & Alport, 1999) and little research has been done supporting these inhibitory processes in bilingual language comprehension. In order to address the research questions concerning cross-language interactions and the inhibitory control mechanism involved in resolving between-language competition, it is important to use experimental paradigms that attempt to further clarify the processing issue related to the control processes involved in language selection (Wu & Thierry, 2010).

In connection with this idea, the present dissertation aimed to contribute to advance in the research on these processes. In this sense, the procedure we used along our studies allowed us to obtain two independent indexes. On one hand, the interference effect found in response to interlexical homographs was taken as an index of the non-selective activation of the two homograph meanings. On the other hand, the delay observed in response to trials that required the reactivation of the irrelevant meaning of the homograph, presented in a previous trial, was taken as an index of the homograph non-target meaning inhibition. This methodological feature is important in order to explore the processes of interest in a more specific way. Moreover, this procedure has advantages over those used in previous studies in which the findings sometimes are based on indirect measures of the inhibitory effects and in the use of mixed language conditions (Meuter & Alport, 1999). In addition, unlike some previous studies on homograph processing, the studies presented in the present work are carried out in only one language context (i.e., the participants' L2, English) what allows to perform the task without biasing toward either the Spanish meaning or the English meaning of interlexical homographs (Beauvillain & Grainger, 1987).

In this dissertation, we investigated cross-language activation and language selection processes. The interference effect found in the first trial indicates that bilinguals activated the two homograph meanings because they slowed their responses when the word pair included an interlexical homograph whose Spanish meaning was related with the word of the pair (Chapters III-V). This finding is consistent with previous studies involving interlexical homographs in language comprehension and provides further evidence for the theoretical perspective that the lexical access in bilinguals is fundamentally language non-selective (De Bruijn et al., 2001; Dijkstra et al., 2000; Dijkstra et al., 1998; Kerkhofs et al., 2006). As we mentioned in Chapter III, previous studies have failed to observe differences between homograph and control words when bilinguals perform a lexical decision task in their L2 (e.g., Dijkstra et al., 1998). However, we also observed this interference effect when critical words were presented alone in a lexical decision task (Experiment 2, Chapter III).

One important finding in the present work, and most relevant for the main goal of this dissertation, is that, after activating the two meanings of a homograph, bilinguals slowed their responses when its Spanish meaning became relevant in the second trial, indicating that this irrelevant meaning was inhibited (Chapters III-IV; and Experiment 1, Chapter V). Given the interference effect stemming from the parallel activation of the two homograph meanings, the bilinguals resolved the interference by suppressing the non-target and competing homograph meaning in order to select the appropriate one. Importantly, this inhibitory effect was observed (1) after responding to homographs in the previous trial, (2) when the non-target meaning of the previously presented homograph became relevant in the following trial, and (3) when the interlexical homographs were presented both embedded in word pairs and in isolation. This pattern of results agrees with the inhibitory hypothesis of meaning selection in bilingual language processing. As we already mention in the discussion of the empirical chapters of this dissertation, the inhibitory effect observed in the second trial of our studies (Chapters III, IV and Experiment 1, Chapter V) could be interpreted as a result of a competitive process between the two active meanings of the homographs according to the Inhibitory Control model (Green, 1998). However, this inhibitory effect could be explained by an alternative and non-inhibitory account (Neill, 1997; Neill & Valdes, 1992). According to the episodic retrieval account, the participants may encode the stimuli presented in the task in a memory trace in which the stimuli are represented along with the potential response associated to them. For example, in the context of our experimental task, the relevant meaning of the homograph (i.e., the English meaning) would be encoded as a "respond" item, while the irrelevant meaning (i.e., the Spanish meaning) would be encoded as a "do not respond" item. Afterward, the second presentation of the irrelevant meaning would act as a cue to retrieve the previous episode in which it was processed. Thus, the response delay observed when the irrelevant meaning of the homograph is presented in the second trial could be due to the conflict created between two different encoded episodes: the irrelevant homograph meaning associated to a "do not respond" tag, and the same meaning associated to a "respond" tag (corresponding to the first and second processing of that meaning, respectively). From the episodic retrieval account, the probability to observe interference depends on the degree to which the second presentation of an item works as an effective cue to retrieve the last time this item was encountered. This possibility was tested by Macizo, Bajo, and Martín (2010; Experiment 2). The authors carried out an experiment in which the strength of the second presentation of the homograph meaning as a cue was weakened by changing its associated response. Therefore, in the first trial the irrelevant homograph meaning was associated to a related word and to "yes" response (e.g., "foot", the Spanish meaning of "*pie*" was related to "*toe*") while the irrelevant meaning was associated to an unrelated word and to "no" response in the second trial ("*foot*" and "*present*" are unrelated). The results indicated that the interference effect was again observed under these circumstances in which response tag was not an effective cue to retrieve previous occurrence of the homograph. Therefore, the pattern of results found by Macizo et al. indicated that the effects observed in the second trial are better explained by the inhibitory account.

The evidence of inhibitory processes observed in the present dissertation can be also explained according with other models of bilingual language comprehension (see Thomas & Van Heuven, 2005, for a review). In Chapter I, we briefly introduced the Bilingual Interactive Activation model (BIA model, Dijkstra & Van Heuven, 1998; BIA+ model, Dijkstra & Van Heuven, 2002). The BIA model proposes that letter features and letters that are part of a word non-selectively activate lexical candidates in all bilingual's languages. These candidates also activate language nodes to which they are connected. In this model, inhibition is implemented by two mechanisms (a) lexical candidates inhibit other candidates from the same language (lateral inhibition) and, (b) language nodes inhibit the activation of lexical candidates from another language. According to this model, the inhibitory effect observed in our studies might be interpreted as a consequence of the English language context used in the experiments. Also, lateral inhibition would be acting to suppress activation of representations in the non-intended language. In our study, lexical candidates were activated in Spanish and English and the English language node was also activated because of the English context used in the experiment. This English language node in turn would suppress the activation of Spanish lexica candidates. In addition, the idea of lateral inhibition would imply that lexical entries in L2 would reduce activation of L1 representations. The results obtained in the current study cannot dissociate the relative weight of these two inhibitory mechanisms (language nodes and lateral inhibition), however, after this interactive process of activation and inhibition, the most active lexical candidate was the English interpretation of the interlexical homograph.

One important issue in bilingual processing that is still under debate is related to the level of processing (e.g., lexico-phonological, lexico-semantic) on which inhibitory control processes act in language selection. Although the task we used in our studies is lexico-semantic in nature (the participants processed visual words and the task was based on word meanings), the phonology of the homograph two meanings could be involved also in the performance of the task. In this sense, the evidence provided by previous studies suggests that the phonological similarity between a target stimulus in one language and a word from the non-target language can influence bilingual processing (Brysbaert, Van Dyck, & Van de Poel, 1999; Dijkstra, Grainger, & Van Heuven, 1999; Schwartz, Kroll, & Diaz, 2007; Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011). Dijkstra et al. manipulated the degree of orthographic, phonological, and semantic overlap of English words in relation with Dutch words. In their study, Dutch-English bilinguals were asked to perform a progressive demasking task and a visual lexical decision task. Facilitation effects of cross-linguistic orthographic and semantic similarity were found in response to target words; in contrast the effects of phonological overlap were inhibitory. The authors indicated that this phonological inhibitory effect arose because participants activated two different phonological representations in their two languages that may compete at the lexical level. Since the phonology was not informative to perform the experiment, participants might attempt to avoid the competition between both activated alternatives resulting in a response delay to the item in the target language.

Hence, one concern that could be argued about the findings reported in this thesis has to do with the role of phonology on the cross-language effects we observed. The stimuli used in our studies included identical interlexical homographs with total orthographic overlap. However, the degree of phonological overlap between the two meanings of the homographs varied across the stimulus set. For example, among the stimuli there were homographs whose pronunciation was similar (e.g., *red*: color and fishing tool; /red/ and /reð/, for the English and Spanish pronunciation, respectively), and in other cases not (e.g., *pie*: food and part of the body; /paɪ/ and /pie/, for the English and Spanish pronunciation, respectively). If the presence of interlexical homographs with a pseudohomophonic status influences the performance of the bilinguals, then we can conclude that interlexical homographs lead to the parallel activation of the phonological representation of both homograph meanings. It could be argued that the interference effect might be modulated by the degree of phonological similarity of lexical forms of homographs. Since the semantic decision task used in the experiments required the retrieval of word meanings, the activation of phonological representations in the non-intended language might favour the activation of the irrelevant homograph meaning. Thus, phonology might modulate the interference effect observed in our experiments.

The relative contribution of phonology in between-language activation is also addressed in the framework of the BIA+ model (Dijkstra & Van Heuven, 2002). Dijkstra and Van Heuven (2002) extended the Bilingual Interactive Activation model including phonological and semantic representations in the word identification system. The BIA+ model assumes that word recognition can be affected by orthographic, phonological and semantic information. Moreover, the connections among these three codes are interactive and bi-directional within the identification system. For instance, the activation of orthographic representations in one language can in turn activate associated phonological and semantic representations in the alternative language. The information coming from the activation of relevant codes in the identification system can influence the task/decision system. In the context of our studies it might be possible that the participants activate the phonological codes of a homograph as well as the semantics. For example, if a homograph like *pie* is presented, bilinguals can activate the phonology associated to the Spanish meaning /pie/, which in turn could activate the semantic code in Spanish (i.e., pie as a part of the body). As the model assumes that the connections among these three codes are interactive and bi-directional, the Spanish meaning of *pie* can activate in turn the English meaning *foot*. The activation of this meaning could produce a conflicting situation, leading to an incorrect response. If the activation of *foot* is reduced to select the correct response in the first trial, then, when it is presented in the second trial it has to be reactivated, taken more time to respond in this condition. At this point, we cannot be confident about the locus of the interference effect observed during the processing of interlexical homographs. Future research is needed to unravel the nature of this interference effect. The degree of phonological/orthographic between-language overlap would be tracked to determine the locus of interference effects obtained in our dissertation work.

In Chapter IV we aimed to explore the cortical activity associated to the language selection processes. The use of the ERP technique has provided neurocognitive researchers with a useful brain measure with a high temporal resolution to explore the mechanisms of language control, as well as the neural correlates of bilingual language processing. We used this technique (Chapter IV) to continue exploring the processing of interlexical homographs. The pattern of results showed that the cross-language activation was reflected on the ERP modulation associated with the processing of interlexical homographs relative to control words in the 450-600 ms time window on a midline scalp distribution. In addition, more negative amplitudes were observed when the irrelevant homograph meaning previously inhibited was required in the subsequent trial. This ERP modulation was observed in the 300-450 ms time window with a right frontal scalp distribution. The latency and scalp distribution of the electrophysiological differences observed in our study were consistent with the results obtained in previous studies on interlingual homograph processing (De Bruijn et al., 2001; Paulmann et al., 2006) and they correspond to the typical time window in which the N400 component is observed.

It should we mentioned that other important ERP component that has been related to response suppression or inhibition is the N200 component. This component has been taken as an index of response inhibition mainly by using the *go/no-go* paradigm. Although the N200 is not properly a language-specific ERP effect, it has been associated to cognitive control and inhibitory effects in bilinguals (Moreno, Rodriguez-Fornells, & Laine, 2008). In general, the overall pattern of results about N200 effects obtained from bilingual studies using *go/no-go* tasks reveals larger negativities with the latency at about 400 ms in response to conditions of cross-language interference especially at frontal and medial locations (Rodriguez-Fornells, De Diego Balaguer, & Münte, 2006). This long-lasting negativity has been interpreted as an index of the amount of executive control needed to perform a certain task. In the context of our experimental task the bilinguals had to select the target meaning between two activated lexical candidates. The selection of the target meaning of the homograph in the less dominant language may involve the inhibition of the non-target meaning in the more dominant L1 (Green, 1998). In this sense, although we do not find properly N200 effects in our study, we can argue that the negative modulation related to the homographs processing in fronto-central locations may be reflecting the increased control required to cope with conflicting information (Moreno et al., 2008). In addition, enhanced control might be required to overcome inhibition when the previously inhibited meaning is required in the following trial. Furthermore, according with previous evidence on N400 effects, the negative modulation observed in the second trial of the task in the N400 time window may be reflecting the difficulty to reactivate that meaning and to integrate that lexical item in the current context (Kutas, Van Petten, & Kluender, 2006).

Leaving aside the methodological differences due to the event-related potentials recording requirements in the study included in Chapter IV, the behavioural results corroborated the results that we found in Chapter III. In addition, the ERP modulation associated with the processing of interlexical homographs further supports at the electrophysiological level the findings on control processes in language comprehension previously discussed, providing a more time sensitive measure of the cross-language interaction effects reported in our studies.

In Chapter V we further investigated an issue related to the nature of inhibitory control processes: their time course. As we have mentioned before, in the framework of bilingual research it has been widely shown that bilinguals access to lexical representations of the L1 and L2 in a language non-selective manner (Dijkstra, 2005). Furthermore, a growing set of studies suggests that language selection may rely on an inhibitory control mechanism that allows bilinguals to select the appropriate representation when lexical alternatives are active and compete for selection. As we have previously mentioned, overcoming inhibition may take time and it can suppose a cost in the bilinguals' performance. Given that this situation may occur very often in the daily life of the bilingual population, one important question to address is how long this inhibitory effect lasts.

To investigate how long the inhibition effects can be observed, we carried out two experiments (Chapter V) in which we focused on the interval between the time in which interference was produced by the non-selective activation of the two homograph meanings and the presentation of the previously inhibited irrelevant homograph-meaning. The pattern of results showed that the inhibitory effects were very short lived since they were observed in a time interval between 500 ms and 750 ms. After a time interval of 750 ms, bilinguals seem to have recovered from inhibition. These findings indicate that inhibition seems to be a process involved in the resolution of between-language competition, and this inhibition has transient effects. However, these effects are observed while bilinguals processed interlexical homographs out-of-context, whereas bilinguals rarely use their languages in such a context. A way to test the validity of these findings is to extend this research to a more meaningful context. To this aim, we carried out a new study in which bilinguals processed interlexical homographs in a sentence context. In this study these stimuli were presented at the end of low-constraint sentences in the participant's L2, English (e.g., *She liked Peter's pie*). Next to the presentation of the final word in the sentence, participants performed a judgement relatedness task in the presence of a target word that could be related or not to the sentence meaning. As in our previous experiments, the critical manipulation consisted of the presentation of the Spanish translation of the homograph that was previously presented in the sentence (e.g., *foot* / *log*; *foot* is the critical word and *log* the control word; note that in both cases the correct response is "no"). We manipulated the time interval that elapsed from the presentation of the critical word in the sentence to the presentation of the target word (e.g., 500 ms or 750 ms after the sentence's final word presentation). Although the results of this study are not included in the present dissertation, preliminary results are in consonance with our previous findings (Martín, Macizo, & Bajo, 2011). Bilinguals experienced interference in the presence of homographs as compared to control words and this effect was only observed at the short time interval. In addition, the results of a control experiment with English monolinguals showed no differences among conditions. The overall pattern of results further extends our previous findings to homograph processing in a sentence context.

Although some studies have found long-lasting inhibitory effects of L1 representations in bilinguals (Levy, McVeigh, Marful, & Anderson, 2007), there are methodological reasons that can explain the differences on time-span inhibition regarding our findings (see the general discussion section in Chapter V). Therefore, Levy et al. suggest that the inhibitory effects observed in their study come from the inhibition of phonological representations. In our studies, we can not discard that in the presence of interlexical homographs, phonological representations of their two meanings become activated in parallel, besides the activation of the lexico-semantic representations. Although the locus of the inhibitory effect obtained in our study is unclear (see previous discussion on this point), given the semantic nature of the task used in our experiments, it is more plausible to think that the inhibitory mechanism might be acting on the semantic level of representation.

To our knowledge, the time course of inhibitory processes on bilingual language processing has not been directly addressed on bilingual research. We hope that the findings in Chapter V provide new insights regarding cognitive control processes in bilinguals that promote future research about the functioning of the bilingual language system.

MODULATING FACTORS OF INHIBITORY PROCESSES ON BILINGUAL LANGUAGE PROCESSING

In the final empirical chapter of this thesis (Chapter VI) we investigated the influence of immersion in an L2 environment and expertise in translation on cross-language activation and inhibitory processes in language selection. To this aim, we tested three groups of Spanish-English bilinguals who differed in their language environment (L2 immersion vs. L1 immersion) and their experience in professional translation. The pattern of results revealed a modulator effect of these factors on the processes of interest.

Immersion in L2 context

The findings in this chapter suggest that the language environment in which a bilingual is immersed might modulate lexical access. The results indicated that only the Spanish-English bilinguals immersed in their L1 showed the interference effect while processing interlexical homographs. Furthermore, after responding to homographs, they showed the inhibitory effect in the second trial. Unlike the L1 immersed bilinguals, the Spanish-English bilinguals immersed in their L2 did not show the interference nor the inhibitory effects. The absence of these effects in the L2 immersed group suggests that their immersion context might produce a modulator effect on cross-language interactions by reducing L1 activation and consequently between-language competition.

As we discussed before (see the discussion section in Chapter VI), these findings could be explained by the frequency of usage of two languages (e.g., "weaker links" account; Gollan, Montoya, Cera, & Sandoval, 2008; Gollan, Montoya, Fennema-Notestine, & Morris, 2005) and the continuous inhibition of the non-practiced L1 (Levy et al., 2007). In addition, there are other possible accounts. As the bilinguals continue exposed to their L2, the immersion context might act as a strong language cue favoring the activation of the L2 because it is the language they need to use. According to the BIA model model (Dijkstra & Van Heuven, 1998), words candidates activate the language node to which they are connected and language nodes are activated to different degrees depending on language context. Thus, language context might act a "language tag", affecting the relative activation of the language nodes and leading to a change in the resting level activation of words from both languages of a bilingual depending on the frequency of use of each of them. In addition, if context affect the relative activation of the language nodes, the subsequent suppression by these nodes of words from another language might change the relative activation of words from the different languages. In this line, it can be argued that when Spanish-English bilinguals are continuously immersed in their L2, activation of Spanish words could be reduced or partially suppressed. Previous studies have shown that just a very brief exposure to one language modulates the subsequent activation of the bilinguals' languages (Paulmann et al., 2006; Elston-Güttler, Gunter, & Kotz, 2005). For example, Elston-Güttler et al. (2005) showed that after watching an English movie during 20 minutes, German/English (L1/L2) bilinguals found themselves in a L2 environment and, afterward, there were reduced effect of L1 on L2 during the processing of homographs relative to a condition in which bilinguals were exposed to German movies. Thus, linguistic context served as cue that modulated the activation of the bilinguals' two languages. The task effects observed in this study were considered by the authors as a global context effect. Moreover, they suggest that 20 minutes of L2 exposure are enough to reduce the influence of the L1 on the L2. However, some important differences arise between Elston-Güttler et al.'s study and ours. It is important to note that our findings refer to bilinguals who were tested while they were currently immersed in their L2 and for a substantially longer period of time. Moreover, we consider that the global language context is not related to the experimental context but to a more daily life language immersion.

Although global inhibition may explain the lack of activation and inhibition effect in the immersed group of our study, the relative frequency of usage of the two languages and immersion as a strong contextual cue might also have some role in explaining our results. Further research is needed in order to clarify the way in which some of these modulating factors might influence each other.

Expertise in translation

In Chapter VI we explored whether the experience in translation may have an impact on bilingual language processing. Concretely, we were interested in expertise in translation as a modulating factor of control processes in language selection. The findings concerning this factor indicated that experienced translators showed between-language activation but no inhibitory effect. As already mentioned in the discussion section of Chapter V, previous findings in the field suggest that translators, due to their extensive professional practice in translation, might develop greater efficiency in L2 processing than ordinary bilinguals (Christoffels, De Groot, & Waldorp, 2003; Macizo & Bajo, 2006; Padilla, Bajo, & Macizo, 2005). In this sense, our findings together with the results of a recent study, suggest that translators' ability may rely more in the maintenance of their two languages active rather than the use of inhibitory processes (Ibáñez, Macizo, & Bajo, 2010).

In addition, there is compelling evidence showing that bilingual experience confers advantages to cognitive processing and executive control (Bialystok, 2007; Bialystok & Craik, 2010; Bialystok, Craik, Klein, & Viswanathan, 2004; Christoffels, De Groot, & Kroll, 2006; Colzato, Bajo, Van den Wildenberg, Paolieri, Nieuwenhuis, La Heij, & Hommel, 2008; but see Hilchey & Klein, 2011, for a recent review about considerations on the cognitive advantages in bilinguals). From this corpus of evidence, it can be argued that the extensive experience in translation makes translators become individuals with a special training in executive control and to develop greater efficiency in L2 processing than ordinary bilinguals. Evidence in favour of this argument comes from studies showing larger working memory capacity, better dual task performance in verbal tasks (Padilla et al., 2005) and smaller code switching cost (Ibáñez et al., 2010) than either monolinguals and bilinguals.

CONCLUDING REMARKS AND FUTURE RESEARCH QUESTIONS

In this dissertation we attempted to provide evidence for the presence of inhibitory control processes in language selection in bilinguals and to investigate the influence of some related factors on these processes. The studies included in the empirical chapters demonstrate that Spanish-English bilinguals activated the two meanings of an interlexical homograph, and that the selection of the relevant meaning involved the inhibition of the non relevant meaning. In addition, the experimental manipulation included in Chapter V allowed us to observe how long inhibition extends in time. It seems that inhibition is involved in language selection, but its consequences have a transient effect. Furthermore, in Chapter VI we focused on two important factors that might impact on bilingual language processing. The findings in this chapter revealed the influence of the language immersion context and the expertise in translation of the bilinguals on language activation and language selection processes.

However, several research questions are not fully addressed in this work. For instance, we consider important to investigate whether proficiency and the relative dominance of the bilinguals' languages modulate cross-language interactions. Previous studies that have already addressed this issue suggest that bilinguals with different levels in proficiency may show differences in the pattern of language co-activation and language selection processes (Costa & Santesteban, 2004; Elston-Güttler, Paulmann, & Kotz, 2005). In most of the studies of this dissertation we attempted to asses the participant's proficiency by using objective measures (i.e., the Oxford Quick Placement Test; Oxford, 2004). However, in the experiments included in Chapters III and VI, the participants completed a self-rating questionnaire about their proficiency and language history. This fact may be relevant especially in the case of the L2 immersed bilinguals. Although the groups in this study were matched in proficiency, it could be possible that the subjective measure in proficiency does not capture confidently possible differences among groups in this factor that could provide an alternative account for the pattern of results observed in the L2 immersed bilinguals group. Moreover, it is possible that a continued experience of immersion in a second language environment may confer a higher level of proficiency in L2 or lead to a shift in the relative dominance of the bilingual's languages (L1 vs. L2). If the relative dominance of the bilinguals can change from their L1 to the L2 as a consequence of an extensive period of L2 immersion, in this case they could behave as L2 monolinguals as the influence of their previous more dominant L1 over their L2 is reduced. Thus, the lack of language co-activation observed in the L2 immersed bilinguals, rather than reflecting the global inhibition of the L1, might reflect a reduced level of L1 activation due to a change in their languages' dominance. Further research on this factor will help to develop improved methods to assess proficiency and relative dominance of the bilinguals' languages.

The present dissertation provides evidence of the presence of inhibitory processes in language selection. However, these findings were observed while bilinguals processed interlingual homographs out-of-context, whereas bilinguals rarely use their languages in such a context. As we briefly outlined above in this chapter, we are performing a series of experiments to explore language selection processes during the processing of interlexical homographs in sentence context. Previous research in bilingual language processing has showed that the sentence context in which a word is embedded may modulate cross-language activation. In addition, non-selective activation and selection processes may be influenced by the language context, the semantic constraint of the sentence or by the stimuli characteristics (among other factors) (see Degani & Tokowicz, 2010, for a review). Preliminary results in these studies extend our previous findings on cross-language activation and inhibitory control processes to sentence comprehension. The sentences used in these experiments were semantically low-constraint sentences; however it would be interesting to explore whether a high-constraint sentence context may modulate the processes of interest. Recent evidence on sentence processing shows that a semantically constraining context does not restrict the degree of language activation of the non target language (Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011) but mixed results arise depending on the semantic constraint of the sentence and the type of stimuli used. For instance, some authors have found cognate effects only in low-constraint sentences (Van Hell & de Groot, 2008; Schwartz & Kroll, 2006) whereas others have found these cognate effects in both high- and low-constraint sentences (Libben & Titone, 2009; Van Assche et al., 2011). However, studies using interlexical homographs embedded in high- and low-constraint sentences have found different results. While some authors have found homograph effects in low-constraint sentences (Libben & Titone, 2009; Van Hell & de Groot, 2008), other have found this effect neither in low-constraint nor in high-constraint sentences (Schwartz & Kroll, 2006). We consider that further research is necessary to clarify the role of the language context (L1 vs. L2) and the semantic constraint on bilingual lexical access and their modulator effect on language selection processes.

Finally, the findings concerning the translators group in Chapter VI raise an interesting research question about the language selection processes used by this bilingual population. In our study, experienced translators showed between-language activation but no inhibitory effect. Similar results were obtained by Ibáñez et al. (2010), which suggest that translators may develop the ability of maintaining their two languages active. Although speculative, this ability could make them to deal with this parallel activation without experiencing between-language competition, and so they would not need to use inhibitory processes to select the language they need. In addition, it can be argued that the special training in executive control that entails an extensive experience in professional translation makes translators to process their languages in a more efficient way. A relevant question to be explored in future studies is whether this population does not use inhibitory processes in language selection, or whether they use them in a more efficient way. A future line of research may be linked to the findings in Chapter V on the time course of inhibitory processes in language selection. For instance, by investigating the time course of cross-language interactions we might clarify whether the differences found in translators are related to a different time course of both language activation and the recruitment of inhibitory processes to solve between-language competition. The use of techniques with a high temporal resolution, such as eyetracking or ERPs, might help to disentangle this question.

We hope that the empirical findings reported in the present work provide new insights regarding cognitive control processes in bilinguals that promote future research about the nature of these processes to better understand the functioning of the bilingual language system.

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CHAPTER VIII

APPENDICES

A. Materials used in the semantic relatedness task.

First trial			Second trial		
Homograph	Control	Unrelated	Translation	Control	Related
pie	log	toe	foot	finger	hand
grape	peach	together	staple	pen	paper
tender	walnut	rope	hang	neck	noose
as	it	poker	ace	rummy	cards
vine	worm	depart	arrive	midnight	late
pan	fox	butter	bread	biscuit	dough
pillar	bovine	throw	catch	cod	fish
red	dark	tennis	net	hit	ball
cave	cage	ditch	dig	hoe	shovel
done	door	money	donate	hope	charity
mate	rent	shine	dull	color	bright
more	so	live	dwell	address	home
come	since	chew	eat	thin	fat
fin	rut	finish	end	start	begin
dame	bulb	receive	give	selfish	share
sane	stag	cure	heal	cut	wound
talon	snail	ankle	heel	sandals	shoe
sale	coat	goodbye	leave	stop	go
lame	edit	suck	lick	candy	lollipop
mayor	glad	street	main	fence	gate
case	among	divorce	marry	hate	love
collar	clever	bracelet	necklace	silver	gold
actual	hell	now	current	new	recent
are	you	field	plough	cropping	farmer
tire	joke	shove	push	tug	pull
meter	cling	place	put	buy	get
eleven	notion	lower	raise	carry	lift
lean	tent	book	read	word	write
quite	body	erase	remove	repair	replace
arena	fatty	castle	sand	shore	beach
dice	debt	talk	say	language	speak
son	care	hear	sound	rock	music

time	two	thief	steal	bank	rob
gusto	allay	smell	taste	mouth	tongue
ate	bake	bow	tie	string	knot
tea	fist	fire	torch	switch	light
sauce	alike	weeping	willow	bush	tree
con	ski	along	with	in	out
sin	rear	not	without	alone	empty
liar	matt	cover	wrap	Christmas	present

Note. Homograph: Spanish/English interlexical homographs used in the homograph-unrelated condition of first trial. *Control:* Unrelated control words that substituted homograph in the control-unrelated condition of first trial. *Unrelated:* Unrelated words used in the homograph-unrelated and control-unrelated conditions of first trial. *Translation:* English translations of Spanish homograph meanings used in the translation-related condition of second trial. *Control:* Related control words that substituted translations in the control-related condition of second trial. *Related:* Related words used for the translation-related condition of second trial.

B. Materials used in the English lexical decision task (Experiment 2, Chapter III).

First trial		Second trial		Non-words	
Homograph	Control	Translation	Control	English	Spanish
pie	log	foot	finger	tamquil	era
grape	peach	staple	pen	hubcho	borde
tender	walnut	hang	neck	stygsum	mata
as	it	ace	rummy	muslid	cae
vine	worm	arrive	midnight	jaunton	por
pan	fox	bread	biscuit	gypment	mar
pillar	bovine	catch	cod	sniva	lado
red	dark	net	hit	crimkey	trazo
cave	cage	dig	hoe	utbast	juego
done	door	donate	hope	sparder	vale
mate	rent	dull	color	scuber	nuevo
more	so	dwell	address	bapka	regar
come	since	eat	thin	fravise	sur
fin	rut	end	start	spingle	pera

dame	bulb	give	selfish	scratrol	tres
sane	stag	heal	cut	buncket	modo
talon	snail	heel	sandals	cosmal	posada
sale	coat	leave	stop	fruset	vote
lame	edit	lick	candy	blama	dos
mayor	glad	main	fence	drammer	dote
case	among	marry	hate	stitar	era
collar	clever	necklace	silver	narrjure	borde
actual	hell	current	new	stosty	mata
are	you	plough	cropping	nackus	cae
tire	joke	push	tug	clugree	por
meter	cling	put	buy	twilo	mar
eleven	notion	raise	carry	draggle	lado
lean	tent	read	word	quogene	trazo
quite	body	remove	repair	roodle	juego
arena	fatty	sand	shore	cliper	vale
dice	debt	say	language	pasket	nuevo
son	care	sound	rock	kidry	regar
time	two	steal	bank	sardril	sur
gusto	allay	taste	mouth	colber	pera
ate	bake	tie	string	bolsy	tres
tea	fist	torch	switch	snupper	modo
sauce	alike	willow	bush	bronsome	posada
con	ski	with	in	frictlet	vote
sin	rear	without	alone	putro	dos
liar	matt	wrap	Christmas	cloiceal	dote
				comdrome	
				manber	
				vetter	
				meches	
				nuon	
				gomine	
				retter	
				uvere	
				ottice	

saraffe
solly
atty
ashop
hooney
doodow
mipple
osin
migay
mypha
midem

C. Self-reported questionnaire about L1 and L2 proficiency used in the experiments.

All participants in the experiments presented here were administered with similar self reported questionnaires about L2 proficiency. The questionnaire was presented in L1 (Spanish) and included questions as follows: *Escribe del 1 al 10 tu habilidad para*… which in English is approximately ‘Choose a score in a 1-10 scale to indicate your ability to…’ This question was formulated for Speaking, Listening, Writing and Reading abilities in L1 and L2. The scores ranged from 1 (less) to 10 (more). The items included in the questionnaire are presented in the following table.

1. Escribe tu número de participante
2. Escribe el día del mes en que estamos
3. Escribe tu teléfono
4. Escribe tu dirección de e-mail
5. Marca tu sexo
6. Marca tu edad
7. Problemas de visión: Uso gafas o lentillas/No/Otros
8. Problemas de lenguaje: Dislexia/Disartria/Otros/No
9. Preferencia manual: Zurdo/Diestro/Ambidiestro
10. Primera lengua
11. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al LEER en tu primera lengua
12. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al ESCRIBIR en tu primera lengua
13. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al HABLAR en tu primera lengua
14. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al COMPRENDER cuando te hablan en tu primera lengua
15. Escribe qué otras lenguas has aprendido o conoces
16. De las lenguas que has escrito justo antes, la que más dominas es
17. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al LEER en tu segunda lengua
18. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al ESCRIBIR en tu segunda lengua
19. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al HABLAR en tu segunda lengua
20. Escribe un número del 1 al 10 (menos a más) indicando tu habilidad al COMPRENDER cuando te hablan en tu segunda lengua

D. The Quick Placement Test (QPT).

QPT scores according to The Association of Language Testers in Europe (ALTE) and the Common European Framework of Reference for Language Learning and Teaching. The results are presented in terms of the six Council of Europe levels (Breakthrough, Waystage, Threshold, Vantage, Effective Proficiency, Mastery), and the Cambridge Examinations.

QPT score	*ALTE score*	*Level*	*Score*
		Council of Europe	*European Framework*
-	0	Beginner	-
30-40	0.5	Breakthrough	A1
40-49	1	Waystage	A2
50-59	2	Threshold	B1
60-69	3	Vantage	B2
70-79	4	Efective Proficiency	C1
80-90	5	Mastery	C2

ALTE levels description:

Council of Europe Levels	*Description*
A1 (ALTE Breakthrough)	A basic ability to communicate and exchange information in a simple way.
A2 (ALTE 1)	An ability to deal with simple, straightforward information and begin to express oneself in familiar contexts.
B1 (ALTE 2)	The ability to express oneself in a limited way in familiar situations and to deal in a general way with nonroutine information.
B2 (ALTE 3)	The capacity to achieve most goals and express oneself on a range of topics.
C1 (ALTE 4)	The ability to communicate with the emphasis on how well it is done, in terms of appropriacy, sensitivity and the capacity to deal with unfamiliar topics.
C2 (ALTE 5)	The capacity to deal with material which is academic or cognitively demanding, and to use language to good effect at a level of performance which may in certain respects be more advanced than that of an average native speaker.