

STRATEGIES OF TEXT COMPREHENSION IN HYPERTEXT

ESTRATEGIAS DE COMPRESIÓN DE TEXTOS EN HIPERTEXTO

TESIS DOCTORAL REALIZADA POR LADISLAO SALMERÓN GONZÁLEZ,

Y DIRIGIDA POR JOSÉ JUAN CAÑAS DELGADO.

DEPARTAMENTO DE PSICOLOGÍA EXPERIMENTAL Y FISIOLOGÍA DEL COMPORTAMIENTO.

UNIVERSIDAD DE GRANADA.

JUNIO, 2006.

Preface	3
1. Introducción	5
1.1 Hipertexto y psicología cognitiva	6
1.1.1 Nacimiento del hipertexto	6
1.1.2. Hipertexto y aprendizaje de textos	6
1.1.3. Estudios sobre la comprensión de textos lineales e hipertexto	7
1.1.4. Influencia del estudio de la comprensión en hipertexto en la psicología cognitiva	8
1.2. La tarea de comprensión de textos en hipertexto	9
1.2.1. Selección del orden de lectura en hipertexto	9
1.2.1.1. Selección estratégica del orden de lectura	10
1.2.1.1.1. Modelo de la carga mental	10
1.2.1.1.2. Modelo de la competición estratégica	11
1.2.1.2. Orden de lectura y coherencia del texto	13
1.2.1.3. Determinantes de la elección del orden de lectura	14
1.2.2 Elección sobre qué secciones del texto leer	15
1.2.2.1. Elección de secciones, elección del orden, y sus efectos en la representación mental del texto	15
1.2.2.2. Determinantes de la elección de secciones para la lectura	16
1.2.3. Adquisición de la macroestructura del texto en hipertexto	16
1.2.3.1. La teoría de la flexibilidad cognitiva	16
1.2.3.2. Construcción de la macroestructura a partir de mapas de contenido	17
2. Justificación y Objetivos	19
2.1. Efectos de la elección del orden de lectura en la comprensión	20
2.1.1. Efectos inducidos por el texto	20
2.1.2. Efectos estratégicos	20
2.2. Efectos del procesamiento de los mapas de contenido en la comprensión	21
2.3. Determinantes de la elección de estrategias de lectura	21
2.4. Efectos diferenciales en la representación mental del texto debidos a la selección de secciones y del orden de lectura	22
2.5. ¿Puede el estudio de las estrategias de lectura ayudar a clarificar la investigación sobre la comprensión en hipertexto?	22
3. Discusión	23
3.1. Efectos de la elección del orden de lectura en la comprensión	24
3.1.1. Identificación de estrategias para la elección del orden de lectura	24
3.1.2. Efectos estratégicos e inducidos por el texto	24
3.1.2.1. Lectores con bajo conocimiento previo	24
3.1.2.2. Lectores con alto conocimiento previo	24
3.2. Efectos del procesamiento de los mapas de contenido en la comprensión	25
3.3. Factores determinantes de la elección de estrategias de lectura	26
3.3.1. Determinantes de la elección de estrategias para la elección del orden de lectura	26
3.3.2. Determinantes de la elección de estrategias para el procesamiento de mapas de contenido	27
3.4. Efectos diferenciales en la representación mental del texto debidos a la selección de secciones y del orden de lectura	27
3.5. Estrategias de lectura e investigación en hipertexto	28
4. Conclusiones	30
4.1. Estrategias de lectura y comprensión en hipertexto	31
4.2. Mejora de la comprensión en hipertexto	31
5. Referencias	33
Appendix I	41
Appendix II	59
Appendix III	84
Appendix IV	98

PREFACE

Introducción

The research described in this dissertation is part of the work that I have carried out during the last four years at the Department of Experimental Psychology at the University of Granada, the Institute of Cognitive Science at the University of Colorado, and at the Laboratory of Quantitative Psychology at the University of Nice-Sophia Antipolis. Our central goal in this investigative project was to explore the cognitive processes involved in hypertext comprehension.

The exposition begins with a few historical remarks about hypertext and psychology, and then turns to the description of the additional reading tasks imposed by hypertext. Relevant studies are then discussed and issues in need of clarification are identified. Following the goals of our research are discussed. Next we introduce the four research papers that comprise the present thesis (appendix I to IV). The first one is intended to explore the role of reading strategies for deciding the reading order in the comprehension of texts. Results points to the importance of semantic coherence of the reading order as a main factor affecting hypertext comprehension. The second one attempts to gain a deeper insight on the nature of this effect, dissociating influences due to text order from those due to strategic components. Data suggest that for readers without prior knowledge, the effects on comprehension are mainly due to text coherence. By contrast, for readers with prior knowledge, comprehension is affected by a mixture of text-induced and strategic effects, related to the activation of their knowledge. The third paper studies the role of metacomprehension abilities as a key factor on the selection of a particular reading strategy. Data reveals that high skilled readers tend to stick to optimal strategies leading to good performance, whereas their low skilled counterparts select mostly strategies leading to poorer comprehension. This result is qualified by prior knowledge: whereas for low prior knowledge readers the selection of strategies is linked to their metacomprehension abilities, for high prior knowledge learners their selection is not related to their metacomprehension skills. Finally, the fourth paper studies how readers processes hypertext graphic overviews, and how this processing is related to comprehension. Analyses of participant's ocular movements reveal that prior knowledge and text coherence are main factors affecting overview processing. In addition, strategies that readers used in order to reprocess overviews affected their comprehension, depending on their prior knowledge and text coherence.

1. INTRODUCCIÓN

1.1 HIPERTEXTO Y PSICOLOGÍA COGNITIVA

1.1.1 NACIMIENTO DEL HIPERTEXTO

En el año 1945 una revista norteamericana publicó un artículo de opinión en el que se instaba a la comunidad científica a afrontar el gran reto para la nueva sociedad en paz: el desarrollo de un sistema de información que hiciera accesible la gran cantidad de conocimiento que existía hasta el momento y que continuaba creciendo en una proporción imparable. Para el autor del artículo los sistemas tradicionales de almacenamiento y presentación de información basados en papel habían dejado de ser viables para mantenerse informado de los avances científicos. La producción científica crecía más rápido que la habilidad en ese momento para estar al corriente de los nuevos descubrimientos. Por ello, el autor urgía a los científicos a desarrollar un sistema que permitiera el almacenaje y acceso rápido y flexible de información, lo que fue la idea embrionaria del hipertexto. Esta arenga a la movilización científica podría haber caído en saco roto, de no ser porque el autor del artículo en cuestión fue Vannevar Bush, el por entonces director de la Oficina para la Investigación Científica y Desarrollo de los EEUU, quien tenía bajo su supervisión a cerca de seis mil científicos dedicados a la creación y mejora de instrumentos de guerra. Con estos antecedentes resulta predecible que los científicos efectivamente acabaran desarrollando el sistema. Lo que quizá nadie podría haber predicho es que el hipertexto (en realidad el conjunto de hipertextos llamado Internet) acabaría siendo uno de los grandes hitos de nuestra sociedad.

1.1.2. HIPERTEXTO Y APRENDIZAJE DE TEXTOS

El hipertexto puede definirse de forma genérica como un conjunto de documentos enlazados entre sí, lo que permite al usuario (e.g. lector) acceder de una sección de texto a otra fácilmente. Según la idea original de Bush, el científico interesado en los avances en una temática específica podría acceder a las nuevas publicaciones en la materia a través de enlaces que se establecerían entre los documentos relacionados. Originalmente profesionales de las áreas de ingeniería y ciencias de la información trabajaron para el desarrollo y mejora de los sistemas hipertexto. No fue hasta los años 1980 cuando la psicología cognitiva, junto con profesionales de las ciencias de la educación y la filología, se empezó a interesar por esta área de investigación (McKnight, Dillon & Richardson, 1993). Esta irrupción se produjo a raíz de considerar la idea de que el hipertexto podría servir no sólo para almacenar y recuperar información de forma eficiente, sino también para facilitar el aprendizaje de información escrita. En este sentido, las primeras propuestas presentaron de manera entusiasta las bondades del hipertexto como sistema de aprendizaje (Delany & Gilbert, 1991; Fiderio, 1988; Jonassen, 1993).

En pocos años, predijeron, el hipertexto reemplazaría por completo al texto lineal para el aprendizaje. Las causas que se arguyeron para avalar al hipertexto como sistema de aprendizaje fueron diversas pero, con frecuencia, se basaban en supuestos laxos y paralelismos vagamente formulados (Dillon, 1996; Tergan, 1997). El hecho de que el hipertexto permita estructurar de forma flexible un texto en diversas secciones enlazadas entre sí por accesos rápidos, se relacionó con la supuesta naturaleza asociativa de la memoria humana (e.g. Delany & Gilbert, 1991). Los autores argumentaban que esta flexibilidad del hipertexto otorga al lector la capacidad de decidir la secuencia óptima de lectura de acuerdo con su propia organización en memoria, al contrario que el texto tradicional en el que el autor establece de forma rígida el orden de presentación de la información. Por ese motivo, se consideraba que el hipertexto podría favorecer el aprendizaje. Sin embargo, este primer entusiasmo no encontró el necesario apoyo empírico en las numerosas investigaciones que se llevaron a cabo para corroborar el supuesto beneficio del uso del hipertexto en tareas

Introducción

de aprendizaje. En realidad, en la mayoría de los experimentos en los que se comparó la comprensión de información en un texto tradicional con la comprensión del mismo texto en formato hipertexto se encontró que el nuevo sistema era peor que el tradicional (Dillon & Gabbard, 1998; Unz & Hesse, 1999). Diversos autores aún comparten esta visión entusiasta (e.g. Shapiro & Niederhauser, 2004) aunque, con frecuencia, aportan experimentos en los que la tarea a realizar es de búsqueda de información (c.f. Chen & Rada, 1996) como único apoyo empírico fuerte para sostener que el hipertexto mejora el aprendizaje con respecto al texto lineal.

Sin embargo, para la gran mayoría de científicos la entusiasta retórica inicial ha dado paso a una etapa de investigación en la que el objetivo principal no es simplemente demostrar que el hipertexto favorece la comprensión de textos. La investigación actual busca evaluar los efectos en la comprensión de las características de los hipertexto y de los lectores. Entre las características del hipertexto que pueden influir en la comprensión caben destacar los mapas de contenidos, la estructura de las secciones del texto, ... mientras que algunas variables individuales estudiadas han sido el conocimiento previo del lector, habilidad metacompreensión, estrategias de lectura (revisiones de la literatura pueden encontrarse en Dillon & Gabbard, 1998; Unz & Hesse, 1999; Shapiro & Niederhauser, 2004).

En ocasiones la investigación en el área ha seguido una aproximación atórica centrada en la mera evaluación de la efectividad tecnológica de varios sistemas hipertexto, si bien es cierto que durante esta etapa se han desarrollado diversas teorías para explicar la comprensión en hipertexto. Entre las más relevantes se encuentran la teoría de la sobrecarga mental (DeStefano & LeFevre, en prensa), la teoría de la competición estratégica (Goldman & Coté, 1990; Goldman, Saul & Coté, 1995), y la teoría de la flexibilidad cognitiva (Jacobson & Spiro, 1995; Spiro, Coulson, Feltovitch, & Anderson, 1988; Spiro, Feltovitch, Jacobson, & Coulson, 1992),

1.1.3. ESTUDIOS SOBRE LA COMPRENSIÓN DE TEXTOS LINEALES E HIPERTEXTO

El estudio de los procesos cognitivos en la tarea de comprensión en hipertexto se nutre no sólo de la reciente literatura en el tema, si no también de numerosa evidencia empírica de temáticas paralelas. Evidentemente, los trabajos en psicolingüística sobre procesos de lectura (e.g. reconocimiento de palabras, acceso léxico...) explican igualmente estos mismos procesos en la comprensión en hipertexto. Esto se aplica también a los procesos de comprensión descritos por las teorías generales desarrolladas a partir de textos lineales (Gernsbacher, 1990, 1997; Kintsch, 1988; 1998). Aunque estos modelos no pueden explicar todos los nuevos procesos de lectura que demanda el hipertexto (como se verá más adelante), sí proporcionan un marco de referencia de incalculable valor para estudiar cómo diversos factores del hipertexto pueden afectar a la comprensión.

Numerosos trabajos han estudiado el papel de distintos factores en la comprensión de textos lineales que resultan ser esenciales en la lectura de hipertextos. En los años 1970 y 1980 se estudió la comprensión de textos cuyos párrafos se presentaban en órdenes diversos (Danner, 1976; Kintsch & Yarbrough, 1982; Lodewijks, 1982; Mayer, 1976; Schnotz, 1982, 1984, 1993). En ese momento, uno de los objetivos principales era determinar el orden de presentación óptimo para favorecer la comprensión, por lo que el orden se manipuló siguiendo diversos criterios: autorregulado frente a determinado, lógico frente a aleatorio, por aspecto frente a por objeto... Aunque en ese momento no se consideró su utilidad para el estudio de procesos de lectura en hipertexto, resultan muy útiles para explicar algunos de esos procesos, ya que la variabilidad del orden de lectura es un factor crítico en la lectura de hipertextos.

Otra de las áreas que adquiere mayor relevancia por su importancia para la lectura en hipertexto es el estudio de los mapas de contenidos (Lorch, 1989; Mayer, 1978; Snapp & Glover, 1990). Los mapas de contenidos son herramientas textuales que presentan de forma esquemática los contenidos de un texto y su organización (Lorch, 1989). La investigación previa ha demostrado que estos mapas pueden mejorar la memoria y comprensión de textos, ya que

Introducción

permiten al lector adquirir la estructura del texto antes de iniciar su lectura (Mayer, 1978). En hipertexto, los mapas de contenido son utilizados frecuentemente para permitir al lector el acceso a las diferentes secciones del texto.

Esta investigación previa resulta de enorme utilidad a la hora de estudiar los procesos de comprensión en hipertexto. En muchos casos, simplemente es necesario aplicar lo que ya conocemos sobre un aspecto de la comprensión (i.e. efecto del orden de lectura en la comprensión), a su homólogo en la comprensión en hipertexto. En otros casos, cuando lo primero no es posible, las teorías y modelos existentes pueden facilitar el desarrollo de hipótesis testables mediante experimentación (i.e. evaluar el efecto de las habilidades de metacomprehenion en la selección del orden de lectura en hipertexto).

1.1.4. INFLUENCIA DEL ESTUDIO DE LA COMPRENSIÓN EN HIPERTEXTO EN LA PSICOLOGÍA COGNITIVA

El estudio de la comprensión en hipertexto también puede influenciar la forma en que la psicología cognitiva aborda el estudio de los procesos cognitivos en la comprensión (Landauer, 1987). La investigación tradicional en psicología cognitiva se ha centrado en los procesos locales de comprensión (i.e. aquellos que permiten enlazar información entre frases adyacentes). La propia naturaleza de la lectura en hipertexto enfatiza procesos de lectura globales (e.g. selección del orden de lectura), por lo que la investigación en hipertexto resalta el papel de las estrategias de procesamiento globales en la comprensión.

Los modelos de comprensión de textos actuales describen fundamentalmente los procesos locales mediante los cuales el lector enlaza la información de cada nueva frase con su representación mental del texto (e.g. Gernsbacher, 1990, 1997; Kintsch, 1988, 1998). Este énfasis en los denominados micro-procesos se fundamenta en la idea de que dichos procesos son la base de la lectura comprensiva (Kintsch, 1988; McKoon & Ratcliff, 1992). Pero aunque se considera que procesos globales (i.e. los que intervienen sobre elementos más allá de frases adjuntas) pueden asimismo intervenir en la construcción de una representación mental del texto, su estudio sigue siendo minoritario (Goldmand & Saul, 1990; Hyönä, Lorch & Kaakinen, 2002). De hecho, los estudios tradicionales sobre micro procesos tienden a minimizar los componentes globales de la lectura mediante dos tipos de estrategias: planteando escenarios experimentales que no requieren de dichos procesos (e.g. textos muy cortos), o promediando los datos de grupos de participantes. Ambas estrategias permiten el control experimental de las variables estudiadas, pero limitan en gran medida nuestro conocimiento sobre el complejo entramado de los procesos que participan en la comprensión de textos. Esta afirmación se puede ejemplificar con una investigación reciente del efecto de información sobre la estructura temática. Según este efecto, los lectores dedican mayor tiempo de procesamiento a las frases que introducen nuevos temas en el discurso, en comparación con las frases que son continuación del mismo tema (Haberlandt, 1980; Haberlandt, Berian, & Sandson, 1980; Hyönä, 1995; Kieras, 1981; Lorch, Lorch, & Matthews, 1985; Lorch, Lorch, & Morgan, 1987; Mandler & Goodman, 1982). El aumento en los tiempos de procesamiento es mayor cuando los cambios temáticos son mayores (i.e. se producen a un nivel supraordinado en la estructura del texto), que cuando son menores (i.e. a un nivel subordinado) (Lorch et al., 1985, 1987). Este efecto se interpreta desde las teorías generales de comprensión como reflejo del establecimiento de un nuevo nodo (o estructura) en la representación del texto (e.g. Gernsbacher, 1990). Hyönä y cols (2002) cuestionaron la universalidad de este proceso, por lo que realizaron un experimento con la metodología de movimientos oculares para explorar posibles estrategias globales en el procesamiento de la información sobre la estructura. Los participantes leyeron dos textos expositivos de longitud media (alrededor de 1200 palabras) con el objetivo de elaborar un resumen de los contenidos tras la lectura, mientras sus movimientos oculares eran registrados. Para estudiar las estrategias globales de procesamiento de los lectores,

Introducción

agruparon a los participantes de acuerdo a su semejanza en diversas variables del procesamiento de cada frase, como la frecuencia y duración de las fijaciones iniciales, de las fijaciones posteriores durante el procesamiento inicial de la frase y de las fijaciones posteriores al procesamiento de la frase. Mediante un análisis de clúster aislaron cuatro tipos de estrategias que denominaron lectura lineal rápida, lineal lenta, revisión no selectiva, y procesamiento estructural. Solamente el último grupo que estaba constituido por el 20% de la muestra (48 estudiantes universitarios) mostraba claramente el efecto de información sobre la estructura temática (i.e. mayor número y duración de fijaciones iniciales en las frases introductorias, y mayor número y duración de fijaciones posteriores en las frases introductorias tanto antes como después de haberlas procesado). Los mismos autores sugieren que el patrón correspondiente al cluster de procesadores estructurales corresponde al efecto normativo identificado a partir de los datos promediados en investigaciones previas (pp. 53-54). Siguiendo la estrategia experimental de promediar los datos, las investigaciones previas habían obviado la complejidad de este fenómeno.

Como se verá a continuación, la lectura en hipertexto impone nuevas tareas para la comprensión con un fuerte impacto en los procesos globales de lectura. Esto requiere tanto el desarrollo y perfeccionamiento de nuevas metodologías para su estudio, como de modelos teóricos para explicar estos procesos. Ambos desarrollos podrían repercutir en un futuro en el estudio de los procesos globales en la lectura lineal.

1.2. LA TAREA DE COMPRESIÓN DE TEXTOS EN HIPERTEXTO

En un trabajo inaugural sobre la comprensión de textos van Dijk y Kintsch (1983) describen la comprensión de textos como la puesta en marcha de distintas estrategias cognitivas con el objetivo de extraer el significado del texto. El lector no se concibe como mero decodificador del significado de las palabras que forman un texto, si no como un procesador estratégico de los elementos locales que configuran el texto. En este contexto, estrategia es un procedimiento opcional y orientado a una meta (Siegler y Jenkins, 1989). Cabe destacar que este modelo de la comprensión de textos se propuso para la lectura de textos lineales, mayoritarios en la época, en los que el lector sigue el flujo de lectura fijado por el propio autor. Pero ya entonces estos investigadores dejaron claro que “nuevos tipos de discurso y formas de comunicación pueden requerir el desarrollo de nuevas estrategias [de comprensión]” (p. 11). De hecho, los procesos cognitivos que intervienen en la comprensión de un texto tradicional también intervienen en hipertexto. Diversas características del hipertexto requieren que el lector realice tareas que no están presentes en la lectura de un texto tradicional, lo que en algunos casos puede suponer la implicación de procesos cognitivos diferentes. Entre estas tareas, que se desarrollarán extensamente a continuación, se encuentra la selección del orden de lectura de las secciones del hipertexto, la elección de qué secciones leer, y la adquisición de la estructura del hipertexto. Otras tareas que proporciona el hipertexto que han recibido atención son las tareas de búsqueda de información y el aprendizaje a partir de elementos audiovisuales (denominados hipermedia). Ambas temáticas constituyen áreas de investigación emergentes, pero quedan fuera del alcance del presente trabajo. Si bien es cierto que en ambas temáticas la comprensión juega un papel principal, en la primera el énfasis se establece en la tarea de búsqueda y no en la lectura per se, mientras que en la segunda el factor de estudio no es tanto el texto cuanto la información audiovisual (o la integración de ambos). El lector interesado puede encontrar revisiones recientes en Chen y Rada (1996) y Mayer (2003).

A continuación nos centramos en las tareas que afectan específicamente a la comprensión de textos en hipertexto.

1.2.1. SELECCIÓN DEL ORDEN DE LECTURA EN HIPERTEXTO

Introducción

La lectura de un texto tradicional se realiza normalmente en el orden propuesto por el autor. Sin embargo, en los hipertextos el orden de lectura no está necesariamente preestablecido. Es más, el hipertexto induce al lector a seguir su propio orden de lectura mediante la inclusión de enlaces en los diferentes nodos o secciones que posibilitan acceder a otras partes del mismo. En el presente trabajo proponemos que la selección del orden de lectura implica al menos dos tipos de factores importantes para la comprensión de la información: factores estratégicos relacionados con la tarea de decidir el orden de lectura, y los factores textuales relacionados con la coherencia del orden de lectura.

1.2.1.1. Selección estratégica del orden de lectura

El estudio de los procesos de selección del orden de lectura ha sido abordado por el modelo de Carga mental (DeStefano & LeFevre, en prensa) y el modelo de la Competición Estratégica (Goldman & Saul, 1990; Goldman et al., 1995).

1.2.1.1.1. Modelo de la carga mental

DeStefano & LeFevre (en prensa) han propuesto que la teoría de la Carga Mental puede describir los procesos de elección de enlaces en hipertexto, concretamente, sus efectos en la comprensión del texto. Este modelo está basado en teorías sobre las estructuras cognitivas, y asume que la memoria de trabajo (i.e. estructura de almacenamiento temporal de información) tiene una capacidad de procesamiento limitada (Baddeley, 1986, 2003). Cuando los lectores aprenden en un hipertexto, dedican recursos de procesamiento a la tarea de comprensión. Si durante esta tarea hay una demanda de recursos cognitivos superior a los disponibles, el sistema se puede sobrecargar, lo que conlleva un mal aprendizaje del texto. La sobrecarga puede darse tanto si el lector no dispone de capacidad de procesamiento suficiente (e.g. baja capacidad de memoria operativa), como si la tarea o el sistema de aprendizaje imponen una carga elevada de recursos. De este modelo se desprende que la selección del orden de lectura se verá dificultada a medida que se aumente el número de enlaces disponibles en el hipertexto. Zhu (1999) evaluó esta hipótesis presentando a un grupo de participantes un mismo texto en hipertextos con menos o más enlaces por página (3 a 7, versus 8 a 12). La comprensión medida a partir de un test de opción múltiple y de un resumen escrito resultó superior para los hipertextos con menos enlaces. Un mayor número de enlaces a procesar podría haber sobrecargado la capacidad de recursos de los lectores, lo que se habría reflejado en una peor comprensión del texto. Una explicación alternativa podría tener en cuenta el patrón de lectura de ambos grupos de participantes. Los participantes de hipertextos con más enlaces podrían tener también mayor posibilidad de seguir órdenes de lectura menos coherentes, lo que como se verá más adelante podría haber interferido en su comprensión. Por desgracia, la autora no describe el patrón de lectura de los participantes, por lo que resulta difícil evaluar esta explicación alternativa.

De la teoría de la carga mental también se desprende que los lectores con menor capacidad de memoria a corto plazo tendrán mayores dificultades de comprensión de un texto en formato hipertexto que en su versión en texto lineal. Lee y Tender (2003) exploraron esta hipótesis, presentando a lectores con baja, media y alta capacidad de memoria operativa, un texto en formato lineal, hipertexto organizado jerárquicamente e hipertexto organizado en forma de red. Apoyando la hipótesis de la carga mental, el recuerdo de información del texto de los lectores de baja memoria operativa fue mayor en el texto lineal que en los dos hipertextos.

También existe evidencia en contra de la hipótesis de la carga mental. Wenger y Payne (1996) utilizaron el paradigma de tarea dual para evaluar de forma directa el papel de la memoria operativa fonológica y visoespacial en la

Introducción

lectura de textos lineales e hipertextos. Bajo la condición de carga verbal, los participantes debían memorizar una serie de dígitos durante la lectura de cada párrafo; mientras que bajo la condición de carga visoespacial, los participantes memorizaban la posición de un signo en una matriz de 4 x 4 zonas. Los autores no encontraron diferencias selectivas de interferencia entre formatos (lineal vs. hipertexto con cinco enlaces) para diferentes medidas de procesamiento on-line (e.g. tiempo de lectura), pero sí para un test posterior de recuerdo de la estructura del texto. Concretamente, encontraron que el recuerdo ordenado del título de las secciones de textos de carácter descriptivo era mayor para la versión en hipertexto que en el texto lineal, bajo la condición de carga de dígitos. Este dato se obtuvo tanto para una serie de textos que versaban sobre temáticas poco familiares (Exp. 1), como para una serie distinta de textos sobre temas más familiares (Exp. 2). En conclusión, la evidencia empírica no permite establecer conclusiones claras sobre la elección del orden de lectura a partir de la teoría de la Carga Mental.

1.2.1.1.2. Modelo de la competición estratégica

El modelo de Competición Estratégica fue desarrollado para describir las estrategias que los lectores siguen a la hora de ‘moverse’ entre los párrafos de un texto (Goldman & Saul, 1990; Goldman, Saul & Coté, 1995), y fue aplicado posteriormente a la lectura en hipertexto (Foltz, 1996). A diferencia del modelo de Carga Mental, se centra en los procesos cognitivos responsables de la selección del orden de lectura. En los experimentos de Goldman y colaboradores los participantes pueden volver atrás o adelante en el texto, y a posteriori se analizan las estrategias seguidas. A nivel global, los autores han identificado tres estrategias: la lectura seguida (lectura lineal sin relectura); revisión (relectura de frases una vez llegado al final del párrafo); y la regresión (relectura de frases antes de llegar al final del párrafo). Los lectores utilizan las diferentes estrategias para moverse dentro del texto. El modelo propone que estas estrategias tienen como objetivo mantener la coherencia local y global de la representación mental del texto, y que las estrategias están moduladas en parte por factores semánticos (e.g. conectores como “por otro lado”) y estructurales (e.g. primera línea del párrafo). En un experimento en el que los lectores podían volver hacia atrás, la mayor parte de relectura antes de la finalización del párrafo (60%) se produjo desde frases señaladas con indicadores semánticos (e.g. enumeración: en primer lugar, en segundo lugar...) (Goldman & Saul, 1990). Asimismo, las relecturas se dirigieron fundamentalmente (65%) hacia frases que introducían o desarrollaban un tema principal. A partir de estos resultados los autores han propuesto el modelo de Competición Estratégica (Goldman & Saul, 1990; Goldman et al., 1995). En este modelo, la elección de a dónde ir en el texto sigue una serie de reglas procedimentales. Estas reglas trabajan tanto a nivel local como global para mantener la coherencia del texto, para reaccionar ante características del texto que sirven como claves de coherencia (tanto semánticas como estructurales), y para elegir la estrategia adecuada cuando el lector no puede establecer relaciones de coherencia entre elementos del texto.

Este modelo ha sido aplicado a la selección del orden de lectura en hipertexto (Foltz, 1996). El autor evaluó la hipótesis principal de este modelo, que aplicado a la lectura en hipertexto asume que el lector decide el orden de lectura entre secciones tratando de mantener la coherencia de su representación mental. Foltz comparó el orden de lectura de un texto de carácter introductorio sobre economía, entre un grupo que leyó el texto en formato lineal (en el que sólo se podía decidir avanzar o retroceder) y otro que lo leyó en formato hipertexto (en el que se podía elegir el orden de lectura mediante enlaces dentro de las secciones o de un mapa de contenidos). Para ambos grupos, entre un 80 y 90% de las transiciones fueron coherentes de acuerdo a la macroestructura del texto. Además, no hubo diferencias en la coherencia del orden entre ambos grupos, lo que apoyaría la idea de que los lectores de hipertexto tratan de “hacer coherente” el orden de lectura (ya que en la versión lineal el orden preestablecido era coherente de por sí). Por último, la coherencia de las transiciones correlacionó positivamente con la inclusión de ideas de carácter macroestructural por parte de los

Introducción

participantes en un resumen del texto.

La coherencia textual parece ser un factor importante tanto en la selección del orden de lectura como en la comprensión final del texto. Sin embargo, diversos estudios cuestionan que el único criterio para seleccionar el orden de lectura sea el de la coherencia semántica. Numerosos trabajos han analizado la selección del orden de lectura en hipertexto a partir de los patrones de transición entre secciones, llegando a la conclusión de que existen diversos patrones de selección (Anderson-Inman & Horney, 1994; Barab, Bowdish, & Lawless, 1997; Barab, Bowdish, Young, & Owen, 1996; Barab, Fajen, Kulikowich & Young, 1996; Barab, Young & Wang, 1999; Britt, Rouet & Perfetti, 1996; Horney & Anderson-Inman, 1994; Lawless & Kulikowich, 1996, 1998; Lawless, Mills & Brown, 2002; Niederhauser, Reynolds, Salmen & Skolmoski, 2000; Rouet, Favart, Britt & Perfetti, 1997).

Una de las clasificaciones más extendidas ha identificado tres grandes estrategias: los buscadores de información, los exploradores de información no-textual, y los usuarios apáticos (Anderson-Inman & Horney, 1994; Barab, Bowdish, & Lawless, 1997; Lawless & Kulikowich, 1996, 1998). El primero corresponde a lectores que se centran en nodos de contenido, el segundo a lectores que se centran en los elementos no-textuales del hipertexto (i.e. mapas, imágenes...) y los últimos a lectores que pasan un corto intervalo de tiempo en secciones de contenido y eligen un orden de lectura arbitrario. Sólo los primeros parecen basarse en la coherencia del texto para seleccionar su orden de lectura. Esta clasificación, aunque varía sensiblemente entre trabajos dependiendo entre otras cosas de los elementos que forman parte del hipertexto (i.e. mapas de contenido, imágenes...) y de la técnica de agrupamiento utilizada (e.g. número de clusters del análisis), permite concluir que la estrategia de selección del orden basada en la coherencia semántica no es la única utilizada por los lectores de hipertexto. En ese sentido, Ainley, Hidi & Berndorff (2002) proponen que los lectores podrían estar basando su decisión sobre qué leer en el interés suscitado por la temática de los enlaces. En un estudio con adolescentes que podían elegir el orden de lectura de una serie de textos, los autores encontraron que parte de ellos elegían primero los textos que habían considerado previamente como más interesantes, dejando para el final los textos más aburridos.

En conclusión, el modelo de Competición Estratégica (Goldman & Saul, 1990) permite describir la conducta estratégica del lector que busca maximizar la coherencia de su representación mental, y sugiere que la selección se basa tanto en factores semánticos como estructurales. Los datos sugieren que este lector estratégico aprende más cuanto mayor es la coherencia de su orden de lectura (Foltz, 1996).

Sin embargo, existen varias limitaciones de la teoría que merecen ser examinadas con detalle. Por un lado, numerosos estudios demuestran que los lectores de hipertexto eligen órdenes de lectura que no consideran la coherencia de las transiciones, como por ejemplo el interés suscitado por un enlace (Ainley, et al., 2002). Aunque aún es una cuestión abierta a la investigación, el criterio de selección del orden basado en el interés podría también beneficiar la comprensión de lectores. Se ha sugerido que un interés alto hacia un texto puede aportar recursos atencionales automáticos a la tarea de lectura, que de otra forma deben asignarse de forma controlada (Hidi, 1990, 1995; McDaniel, Waddill, Finstad & Bourg, 2000). McDaniel y colaboradores presentaron a un grupo de estudiantes universitarios un conjunto de textos narrativos evaluados previamente como muy interesantes o como poco interesantes por un grupo diferente de estudiantes. Durante la lectura los participantes escuchaban una serie de tonos a los que debían responder mediante la pulsación de una tecla lo más rápido posible. En apoyo a la hipótesis de que el interés suscitado por el texto liberara recursos atencionales, la respuesta a los tonos resultó ser más rápida para los textos más interesantes. Es necesario, por tanto, evaluar conjuntamente la utilización de ambas estrategias por los usuarios de hipertexto, así como sus efectos en la comprensión del texto. Numerosos autores sugieren que el efecto del interés se da fundamentalmente para aquellos lectores con cierto conocimiento previo, por lo que esta variable también debería ser considerada (Alexander, Jetton & Kulikowich, 1995; Garner & Gillingham, 1991). Por otro lado, los datos que muestran una

Introducción

correlación entre la selección de un orden de lectura coherente y mejor comprensión del texto (Foltz, 1996) no permiten establecer claramente la naturaleza del efecto. El mismo podría deberse tanto a la estrategia per se (i.e. la estrategia demanda un análisis profundo de las ideas del texto), como por el hecho de que el texto leído sea más coherente en su orden (como se verá a continuación), o por una combinación de ambas. Por último, el modelo postula que las estrategias de lectura se basan fundamentalmente en claves semánticas y estructurales del texto, pero obvia factores cognitivos que podrían ser igualmente importantes. En este sentido, Walczyk y colaboradores han propuesto el modelo de Decodificación Compensatoria, que postula que los lectores con baja habilidad para la decodificación de palabras o baja capacidad de memoria operativa pueden compensar estas limitaciones mediante acciones estratégicas como la relectura (Walczyk, 1995; Walczyk & Taylor, 1996; Walczyk, Marsiglia, Johns & Bryan, 2004). Sirva como ejemplo un experimento con niños de 10 años que debían leer textos tanto expositivos como narrativos, a la vez que emitían sus pensamientos en voz alta. Los resultados mostraron una correlación negativa entre las estrategias de lectura de los participantes (e.g. pausa, relectura, regresión), y las habilidades de decodificación de palabras y de memoria operativa verbal (Walczyk et al., 2004).

1.2.1.2. Orden de lectura y coherencia del texto

Los modelos tradicionales de comprensión de textos, aunque no describen la tarea de selección del orden de lectura, predicen diferencias en la comprensión debido a esta tarea. La gran mayoría de modelos cognitivos de comprensión de textos conciben la tarea de comprensión como el proceso de relacionar ideas de un texto en una representación mental del texto coherente (Gernsbacher, 1990, 1997; Goldman & Varma, 1995; Kintsch, 1988; 1998; van den Broek et al., 1999; van Dijk & Kintsch, 1983; Zwaan, Magliano & Graesser, 1995). Como exponente de este enfoque, el modelo Construcción – Integración (Kintsch, 1988; 1998) describe la comprensión en dos fases: el proceso de construcción genera una red de proposiciones interconectada del texto y la fase de integración identifica los enlaces altamente interconectados a partir de un proceso de propagación de la activación. La información del texto se procesa en series de ciclos. Por lo tanto, para mantener la coherencia entre segmentos, uno o dos nodos con mayor activación al final del ciclo son almacenados en la memoria operativa para estar disponibles en el siguiente ciclo de procesamiento. El modelo distingue al menos entre dos tipos de representaciones mentales que el lector forma del texto: la base del texto, una representación proposicional jerárquica de la información dentro del texto; y el modelo de la situación, que integra la información del texto con el conocimiento previo del lector. De acuerdo con el modelo C-I (así como para muchos de los modelos de comprensión referidos), varios factores contribuyen a la comprensión del texto, pero dentro de ellos la coherencia textual juega un papel determinante. La coherencia textual se forma a partir de características textuales que ayudan al lector a entender y enlazar ideas en el texto, como por ejemplo el uso de conectores (e.g. “por lo tanto”, “sin embargo”) (Lowrse, 2001).

El lector de hipertexto debe conectar las ideas relacionadas pero separadas en diferentes párrafos o nodos para construir una representación mental coherente del texto. La naturaleza no lineal del hipertexto puede dificultar este proceso porque reduce la coherencia global del texto. Es decir, las relaciones entre las ideas relevantes del texto (e.g. de tipo causal, temporal...) no están establecidas de forma inequívoca por la secuencia de presentación de la información como en el texto lineal, sino que el propio lector debe interpretar activamente estas relaciones a partir de su propia navegación en el hipertexto. Como se vio en un apartado anterior, numerosas investigaciones han demostrado que el orden de lectura influye en la comprensión de textos dependiendo de su coherencia (Danner, 1976; Kintsch & Yarbrough, 1982; Lodewijks, 1982; Mayer, 1976; Schnotz, 1982, 1984, 1993).

El orden de lectura podría interactuar con variables cognitivas para la generación de una representación mental

Introducción

coherente del texto. Schnotz (1982) presentó a dos grupos de participantes que variaban en su conocimiento previo del tema un mismo texto expositivo pero en diferentes órdenes. El texto se organizó a partir del criterio “objeto” (exposición de las características de dos teorías por separado para cada teoría), o por “aspecto” (exposición de las características de dos teorías, comparando las teorías para cada característica). El autor argumentó que una organización por “aspecto” contiene numerosos cambios temáticos en el que el objeto varía, por lo que este tipo de organización podría empeorar la coherencia del texto. Los resultados mostraron que los lectores de bajo conocimiento previo efectivamente recordaron más información del texto organizado por “objeto”, mientras que los lectores con mayor conocimiento previo lo hicieron para el texto organizado por “aspecto” (c.f. McNamara, 2001; McNamara, E. Kintsch, Songer & W. Kintsch, 1996; McNamara & Kintsch, 1996). Los lectores sin conocimiento previo no podrían relacionar las ideas en un texto ordenado de forma incoherente sin una guía explícita sobre las relaciones entre ideas, mientras que los lectores con cierto conocimiento previo que siguen un orden muy coherente podrían encontrar el texto demasiado fácil y no activar su conocimiento previo para comprender el texto. En conclusión, la selección del orden de lectura en hipertexto conlleva que el lector pueda leer un texto en un orden de lectura poco coherente (a diferencia del texto tradicional en el que el orden suele preestablecerse de forma coherente), lo que podría afectar a su comprensión del texto dependiendo de su conocimiento previo.

1.2.1.3. Determinantes de la elección del orden de lectura

Tal y como se ha visto en los apartados anteriores, la elección del orden de lectura en hipertexto puede afectar a la comprensión del texto. Por tanto, resulta importante conocer los factores determinantes de la utilización de una determinada estrategia para la elección del orden de lectura. Como se vio anteriormente, para el modelo de Competición Estratégica los “movimientos” en la lectura están guiados por factores semánticos y estructurales, mientras que para el modelo de Decodificación Compensatoria el uso de estrategias está relacionado con las habilidades de decodificación y de memoria operativa.

Roberts y Newton (2001) han propuesto que un factor clave en la elección de estrategias cognitivas son las habilidades metacognitivas. En el caso de la tarea de comprensión este factor se refiere a la capacidad de evaluar la comprensión propia de un texto a medida que se avanza en la lectura del mismo (Son & Schwartz, 2002). El papel de la metacognición en tareas de comprensión ha sido desarrollado por los modelos de Aprendizaje Autorregulado (e.g. Pintrich, 2000). Estos modelos describen los procesos generales que el lector realiza durante una tarea de aprendizaje de texto: el lector establece un objetivo de aprendizaje (e.g. aprender lo suficiente para aprobar un examen), evalúa su comprensión durante la lectura y regula los procesos de lectura cuando percibe una disparidad entre el objetivo establecido y la comprensión actual (e.g. releer una parte mal comprendida). Por lo tanto, para los modelos de aprendizaje autorregulado las habilidades metacognitivas juegan un papel mediador importante en la regulación del aprendizaje.

Existen diferencias individuales en las habilidades metacognitivas, por lo que lectores con habilidades bajas podrían dejar de utilizar estrategias para la mejora de la comprensión (e.g. relectura) a pesar de que su comprensión real del texto fuera deficiente. Es interesante resaltar que tanto para el modelo de Competición Estratégica como para el modelo de Decodificación Compensatoria, las habilidades de metacompreensión juegan un papel primordial en la selección de estrategias, aunque sea de manera implícita. Es decir, en ambos casos el lector reacciona ante diversos factores (del texto o de sus habilidades cognitivas) para poner en marcha las estrategias concretas, pero en ambos casos la estrategia se realiza porque el lector se da cuenta de que no ha comprendido bien una parte del texto (i.e. procesos de metacompreensión).

Introducción

En relación a la lectura en hipertexto, un lector que siguiera un determinado orden de lectura que condujera a una comprensión poco óptima del texto (e.g. un orden de lectura poco coherente), podría cambiar de estrategia para la elección del orden. Sin embargo, para que el lector efectivamente regule su elección del orden de lectura es necesario que posea habilidades metacognitivas suficientes. Aunque esta hipótesis aún requiere ser estudiada, existe evidencia empírica que relaciona las habilidades metacognitivas con la comprensión de textos en hipertexto (Coiro & Dobler, 2006; Moss & Azevedo, 2006; Schwartz, Andersen, Hong, Howard & McGee, 2004; Stiller & Bartsch, 2005).

En un experimento de lectura Schwart et al. (2004) presentaron a dos grupos de estudiantes de bachillerato un texto en hipertexto, bien con un mapa de contenidos totalmente enlazado, o bien con un mapa de contenidos jerárquico. Los resultados mostraron que la comprensión medida con un cuestionario de opción múltiple correlacionaba con las habilidades metacognitivas medidas con un cuestionario. Este resultado se observó solamente en la condición de mapa totalmente enlazado, lo que sugiere que las habilidades metacognitivas son especialmente relevantes cuando la complejidad del hipertexto aumenta.

Por último, el efecto de regulación de las habilidades de metacompreensión en la selección de estrategias es probable que afecte fundamentalmente a los lectores con bajo conocimiento previo de la materia del texto. Investigación previa ha mostrado que dichas habilidades no son determinantes para la comprensión del texto para aquellos lectores con alto conocimiento previo (Borkowski, Carr & Pressley, 1987; O'Really & McNamara, 2002). Por tanto, no deberían ser tampoco relevantes para la elección del orden de lectura.

1.2.2 ELECCIÓN SOBRE QUÉ SECCIONES DEL TEXTO LEER

En ocasiones los textos en hipertexto contienen enlaces a muchos otros documentos, que pueden llegar a formar una red de contenidos de dimensiones ingentes (e.g. enciclopedia multimedia). Por ello el lector de hipertexto debe decidir qué secciones leer y cuáles evitar. De hecho, en muchos de los experimentos sobre comprensión en hipertexto es el propio participante quien decide cuándo ha terminado de leer el hipertexto. Pese a ser un factor relevante para determinar los procesos de comprensión en hipertexto, la elección de qué secciones leerá el participante no ha recibido mucha atención en la investigación.

1.2.2.1. Elección de secciones, elección del orden, y sus efectos en la representación mental del texto

La decisión de qué secciones leer podría estar relacionada con las estrategias de selección del orden de lectura. Si un lector decide seguir un orden de lectura basado en el interés suscitado por los enlaces (Ainley et al., 2001), elegirá primero los enlaces considerados como más interesantes. Además, si está en su mano decidir cuándo acabar de leer, posiblemente evite acceder a las secciones que considere menos interesantes. Sin embargo, es posible pensar que ambas estrategias, la de elección de orden y la de elección de secciones, influirán sobre procesos de comprensión distintos. En el presente trabajo proponemos que la elección de secciones afecta fundamentalmente a la construcción de la base del texto, mientras que el orden de lectura influencia principalmente a la construcción del modelo de la situación. Como se describió anteriormente, la base del texto es una representación de la información expresada en el texto. Parece lógico suponer que dicha representación será más rica a medida que el lector acceda a un mayor número de secciones del texto. Lawless y Kulikowich (1996) distinguieron entre grupos de participantes en un hipertexto de acuerdo al número de secciones accedidas, entre otras medidas. Estos grupos de participantes difirieron en su representación de la base del texto, medida a partir de preguntas basadas en el contenido. El modelo de la situación, por su parte, es una representación generada a partir de la información del texto y el conocimiento previo del lector, como se vio

Introducción

anteriormente. Durante la lectura el lector debe construir esta representación mediante la conexión de cada nueva información a la estructura adquirida hasta ese momento. El proceso de integración de la información en una representación coherente podría verse afectada por el orden de lectura de dicha información. Los resultados comentados previamente de Foltz (1996) relacionando la coherencia del orden de lectura y la inclusión de ideas relevantes en un resumen del hipertexto apoyan parcialmente esta predicción.

1.2.2.2. Determinantes de la elección de secciones para la lectura

Shapiro y Niederhauser (2004) han propuesto que la elección de las secciones puede estar relacionada con las habilidades metacognitivas del lector. Como ocurría con la selección del orden de lectura, los modelos de Aprendizaje Autorregulado permiten describir esta posibilidad (e.g. Pintrich, 2000). Siempre que establezca una meta de estudio elevada para un tema específico, el lector leerá las secciones de ese tema hasta que su comprensión del texto sea la adecuada a su meta. Sin embargo, los lectores con habilidades de metacompreensión bajas tienden a sobreestimar su comprensión del texto (Dunning, Jonson, Ehrlinger, & Kruger, 2003), por lo que seguramente dejarán de leer el hipertexto antes de alcanzar la comprensión de acuerdo a su meta.

1.2.3. ADQUISICIÓN DE LA MACROESTRUCTURA DEL TEXTO EN HIPERTEXTO

La adquisición de la macroestructura del texto es una tarea prioritaria para la construcción de una representación mental del texto coherente (e.g. Kintsch, 1998). En los textos lineales, la estructura del texto viene señalada en parte por el orden de presentación de las ideas (Britton, 1994; Hofmann, 1989). Un texto bien escrito es probable que presente las ideas principales al inicio de las secciones, y que desarrolle dichas ideas a continuación (Garner et al., 1986). Sin embargo, en hipertexto el orden de lectura es heterogéneo, por lo que la construcción de la macroestructura de los contenidos puede requerir de procesos diferentes. La teoría de la flexibilidad cognitiva propone que este proceso se verá favorecido en hipertexto, mientras que las teorías clásicas de comprensión de textos (i.e. modelo C-I) proponen que los lectores deben apoyarse en otros elementos del texto para generar una representación mental coherente (Goldman, 1996).

1.2.3.1. La teoría de la flexibilidad cognitiva

A diferencia de los planteamientos vistos hasta ahora, la teoría de la flexibilidad cognitiva sostiene que la no-linealidad del hipertexto favorece la adquisición de conocimiento (Jacobson & Spiro, 1995; Spiro, Coulson, Feltovitch, & Anderson, 1988; Spiro, Feltovitch, Jacobson, & Coulson, 1992). La teoría sostiene que la información es multifacética y, por tanto, para que el aprendizaje tenga lugar el lector debe considerar a la vez diferentes dimensiones de la información. Por tanto, el lector de hipertexto puede mejorar su comprensión de la información porque este formato no impone una estructura de los contenidos fija.

Jacobson y Spiro (1995) pidieron a dos grupos de lectores que leyeran un hipertexto con varios textos relacionados con el impacto de la tecnología en la sociedad. En un caso, se instruyó a los participantes para que leyeran el hipertexto tratando de identificar un único tema en los distintos textos, mientras que a otro se le instruyó para que identificara múltiples temas en los textos. El grupo instruido a identificar un solo tema respondió a un mayor número de preguntas sobre información textual, mientras que el grupo instruido a identificar diferentes temáticas respondió correctamente a más preguntas de resolución de problemas. Según la teoría de la Flexibilidad Cognitiva, el grupo

Introducción

instruido a identificar varios temas habría generado una estructura de los contenidos más rica y flexible.

Los resultados anteriores revelan que el tipo de objetivos de aprendizaje puede influir en la comprensión de hipertextos, pero no evalúan directamente si la adquisición de la estructura de los contenidos es realmente mejor en hipertexto que a partir de la lectura lineal de textos. De hecho, la evidencia empírica existente sostiene lo contrario, incluso cuando se ha utilizado un hipertexto formado por diferentes textos (y no uno sólo) como en los experimentos de Spiro y colaboradores (Britt et al., 1996). Los autores compararon el aprendizaje de nueve textos históricos que versaban sobre una misma materia, la historia del canal de Panamá. Cuatro grupos de lectores leyeron los textos en diferentes formatos: presentación lineal de los textos o presentación en hipertexto, en orden estructurado o aleatorio. En el formato lineal los participantes leían un texto detrás de otro sin elegir el orden; la presentación con orden estructurado mostraba los distintos textos agrupados bajo subtemas similares (p.e. “planificación de la revolución”, “ejecución de la revolución”), mientras que en la presentación aleatoria los textos se presentaban sin organización aparente. En el formato en hipertexto los lectores leían los textos a partir de enlaces entre los documentos; además, la presentación estructurada incluía un mapa de contenidos jerárquico en el que se hacía explícita la relación entre los documentos, mientras que en la presentación aleatoria el mapa de contenidos no mostraba la estructura de los documentos. Tras la lectura, se presentó a los participantes una serie de ideas importantes expresadas en los textos (y la fuente de las mismas), y se les pidió que recordaran los argumentos y la evidencia que el autor del texto argüía para apoyar la afirmación. Los resultados mostraron una interacción entre las variables orden de presentación y formato: en la presentación ordenada, los participantes recordaron por igual en el formato lineal que en el hipertexto; mientras que en la presentación aleatoria, los participantes en el formato lineal recordaron mayor número de argumentos que los del hipertexto.

Estos resultados revelan tanto que el aprendizaje de la estructura del texto es peor en un hipertexto desestructurado, como que este aprendizaje puede mejorarse si el hipertexto incluye herramientas auxiliares como los mapas de contenido.

1.2.3.2. Construcción de la macroestructura a partir de mapas de contenido

La construcción de la macroestructura del texto implica la identificación de ideas importantes del texto, y su ordenación en la jerarquía de los contenidos (e.g. Kintsch, 1998). Como se comentó anteriormente, los mapas de contenidos son herramientas textuales que presentan de forma esquemática los contenidos de un texto y su organización (Lorch, 1989), de forma que pueden asistir al lector de hipertexto en la construcción de la macroestructura del texto, sobretudo a aquellos que no poseen conocimiento previo sobre la materia. Sin embargo, la evidencia empírica no permite establecer conclusiones firmes sobre el papel de estos mapas en la comprensión de hipertextos (Dillon & Gabbard, 1998; Unz & Hesse, 1999). En ambos trabajos se revisó la literatura empírica sobre el papel de los mapas de contenidos en hipertexto. Para asombro de los autores, se encontraron tanto datos que mostraban que los mapas beneficiaban la comprensión, como datos con efectos nulos y negativos. Además, la investigación en el área ha utilizado fundamentalmente medidas de comprensión off-line (i.e. aquellas tomadas después de la lectura), dejando a un lado las medidas de procesamiento on-line (i.e. aquellas tomadas durante la lectura, como el análisis de los movimientos oculares) (Rouet & Passerault, 1999). Las medidas on-line podrían ser útiles para distinguir los procesos que el lector de hipertexto lleva a cabo para construir la macroestructura del texto a partir de los mapas de contenido.

En definitiva, partiendo de la evidencia empírica actual no es posible describir los procesos por los cuales el lector de hipertexto adquiere la macroestructura de los contenidos a partir de mapas de contenido. Sin embargo, es posible hipotetizar sobre dichos procesos partiendo de la evidencia empírica en otras áreas de estudio paralelas. Como

Introducción

se argumentó anteriormente, la mayoría de los modelos cognitivos sobre la comprensión de textos proponen que tanto el conocimiento previo del lector como la coherencia del texto son factores esenciales en la comprensión del texto (e.g. Kintsch, 1998), y por tanto podrían jugar un papel primordial en el procesamiento de los mapas de contenido.

Investigación previa ha revelado una relación directa entre el conocimiento previo del lector y la coherencia del texto en las fijaciones oculares que los lectores realizan a elementos previamente leídos. Estas regresiones oculares están relacionadas con un fallo en la comprensión del texto (Rayner, 1998), lo que en algunos casos se podría solucionar procesando la información del mapa de contenidos. Concretamente, un mayor número de regresiones y más duraderas se produce cuando el lector posee bajo conocimiento previo en la materia (Kaakinen, Hyönä & Keenan, 2003; Soederberg Miller & Stine-Morrow, 1998; Wiley & Rayner, 2000), así como cuando el texto posee baja coherencia (Rink, Gámez, Díaz & de Vega, 2003; Vauras, Hyönä & Niemi, 1992). Partiendo de estos resultados es posible hipotetizar que el procesamiento de los mapas de contenido será mayor para los lectores con bajo conocimiento previo, así como para los textos con baja coherencia. Igualmente, es posible predecir la construcción de la macroestructura del texto a partir del procesamiento que el lector haga del mapa de contenidos. Si el lector posee un bajo conocimiento previo en la materia, un mayor procesamiento del mapa de contenidos ayudará a generar una representación del texto más coherente, sobretodo cuando el texto sea difícil de procesar (Mayer, 1978). Sin embargo, para el lector con conocimiento previo, el procesamiento del mapa de contenidos puede prevenirle de activar su conocimiento para construir una representación del texto coherente (Shapiro, 1998). En este caso, el lector experto podría aprender menos (McNamara, 2001; McNamara et al., 1996; McNamara & Kintsch, 1996). En cualquier caso, la adquisición de la macroestructura del texto apoyado en el procesamiento de los mapas de contenido es una cuestión abierta a la investigación.

2. JUSTIFICACIÓN Y OBJETIVOS

Justificación y objetivos

Como se ha descrito anteriormente, la investigación sobre los procesos cognitivos en la tarea de comprensión en hipertexto presenta actualmente numerosas limitaciones. Revisiones recientes sobre la literatura empírica no permiten establecer conclusiones sobre qué procesos son relevantes para esta tarea (Dillon & Gabbard, 1998; Shapiro & Niederhauser, 2004; Unz & Hesse, 1999). Nuestra propia revisión de la literatura desde el año 1999 hasta el 2004 describe un panorama similar (Apéndice I). Unz y Hesse (1999) han propuesto que para esclarecer los procesos de comprensión en hipertexto debemos entender la interrelación entre las estrategias de navegación del lector y la comprensión del texto. El presente trabajo tiene como objetivo principal el estudio de las estrategias de lectura propias del hipertexto. A continuación se describen los objetivos concretos en relación al trabajo experimental desarrollado, que se presenta en forma de cuatro anexos (a los que nos referiremos aquí como “estudios”).

2.1. EFECTOS DE LA ELECCIÓN DEL ORDEN DE LECTURA EN LA COMPRESION

Un primer objetivo del presente trabajo es explorar los efectos de las estrategias para la elección del orden de lectura en la comprensión del texto en hipertexto. Para ello proponemos que es necesario diferenciar los efectos inducidos por el propio texto (e.g. debido a la coherencia del orden de lectura) de los aspectos estratégicos (e.g. debido a la propia estrategia). Además, será necesario evaluar la influencia de dichos efectos en las diferentes representaciones mentales del texto, i.e. la base del texto y el modelo de la situación.

2.1.1. EFECTOS INDUCIDOS POR EL TEXTO

En relación al primer tipo de factores, las estrategias de elección del orden de lectura conllevan obviamente que los lectores procesen las distintas secciones del texto en un orden particular. Como se discutió anteriormente, la coherencia del orden de lectura puede influir directamente en la representación mental que genere el lector. Al seleccionar una sección relacionada semánticamente con la anterior, el lector podrá mantener activas las ideas principales de la sección para relacionarlas con las ideas importantes de la siguiente sección (e.g. Budd, Whitney & Turley, 1995). De lo contrario, a medida que la distancia entre dos secciones relacionadas aumenta, las proposiciones relevantes de la primera sección perderían activación en memoria y serían difíciles de enlazar con las proposiciones del segundo texto relacionado. Por tanto, es posible predecir que las estrategias que conlleven la lectura del hipertexto en un orden altamente coherente favorecerán la comprensión del texto, al menos para los lectores de bajo conocimiento previo (Schnotz, 1982). A los lectores de alto conocimiento previo, sin embargo, la selección de un orden de lectura muy coherente podría inducirles a procesar el texto de forma superficial. Dicha relación se explora a lo largo de los distintos estudios del presente trabajo. En los estudios I, II (Exp 1.) y III se evalúa el efecto del orden de lectura elegido por los participantes en su comprensión del texto, mientras que en los estudios II (Exp 2.) y IV el papel del orden de lectura se estudia mediante su manipulación experimental.

2.1.2. EFECTOS ESTRATÉGICOS

En relación al segundo tipo de factores, al menos dos estrategias han sido descritas en la literatura: coherencia e interés (Foltz, 1996; Ainley et al., 2001). La primera consiste en la elección de las secciones basada en la relación semántica entre la sección del texto actual y las demás secciones disponibles. El lector siguiendo la estrategia de coherencia seleccionaría aquella sección que considerara más relacionada. La segunda estrategia, basada en el interés de las secciones, consiste en la elección primero de las secciones consideradas más interesantes, dejando para el final

Justificación y objetivos

aquellas más aburridas. Diversos autores proponen que tanto una estrategia como la otra podrían favorecer la comprensión de textos, sobretodo a los lectores con cierto conocimiento previo. La estrategia de coherencia induce al lector a identificar las ideas principales de una sección, para así establecer el grado de relación semántica entre dicha sección y las otras disponibles. De esta forma, el lector familiarizado con la temática podría superar el procesamiento superficial inducido por un orden de lectura muy coherente mediante este componente estratégico (E. Kintsch & W. Kintsch, 1995; McNamara, 2001). Asimismo, la estrategia de interés podría favorecer la comprensión a partir del interés suscitado por las primeras partes del texto seleccionadas por el lector (i.e. las consideradas más interesantes por él mismo). Como se comentó anteriormente, el interés por un texto induce al lector a utilizar procesos atencionales automáticos al proceso de comprensión, que de otra manera deberían ser puestos en marcha de forma controlada (e.g. McDaniel, et al., 2000). Los efectos estratégicos de la selección del orden (así como su interacción con los efectos inducidos por el orden de lectura), son explorados en el estudio II.

2.2. EFECTOS DEL PROCESAMIENTO DE LOS MAPAS DE CONTENIDO EN LA COMPRENSIÓN

La adquisición de la estructura del texto a partir de los mapas de contenido ha sido estudiada extensamente en la literatura de comprensión en hipertexto, pero en la gran mayoría de los casos la investigación se ha basado en métodos off-line para la evaluación de la comprensión (Rouet & Passerault, 1999). Estos métodos no permiten analizar directamente los procesos de comprensión durante la lectura, una información que podría ser muy útil para esclarecer cómo los lectores adquieren la estructura del texto a partir de los mapas. La técnica del análisis de los movimientos oculares permite el estudio de estos procesos, por lo que en el presente trabajo será utilizada con el objetivo de identificar las estrategias para el procesamiento de los mapas de contenido, y su relación con la comprensión del hipertexto. Es probable que el procesamiento de los mapas interactúe con el conocimiento previo del lector a la hora de generar una representación mental coherente del texto. Los lectores poco familiarizados con el tema de estudio podrían adquirir una mejor representación a partir del procesamiento de los mapas de contenido, mientras que los lectores más familiarizados podrían dejar de utilizar su conocimiento previo si se centraran simplemente en la información de los mapas (e.g. Shapiro, 1998). En el estudio IV se abordan estas cuestiones mediante el análisis de los movimientos oculares de los participantes.

2.3. DETERMINANTES DE LA ELECCIÓN DE ESTRATEGIAS DE LECTURA

El estudio de los factores que determinan la puesta en marcha de una determinada estrategia de lectura en hipertexto no ha recibido demasiada atención hasta el día de hoy. Y ello a pesar de que dichos factores son claves tanto para entender los procesos de comprensión como para mejorar el aprendizaje en hipertexto. Inspirados en modelos de comprensión desarrollados para la lectura de textos lineales (Modelos de Aprendizaje Autorregulado, Modelo de Competición Estratégica, Modelo de Decodificación Estratégica), es posible predecir que tanto factores individuales como del texto puedan influir en la utilización de estrategias.

En el estudio III se investiga el papel de las habilidades metacognitivas en la selección de estrategias para el orden de lectura, en relación al conocimiento previo del lector. Como se vio en un apartado anterior, aquellos lectores con poca habilidad para evaluar y monitorizar su comprensión del texto podrían seleccionar estrategias poco óptimas para su comprensión con mayor frecuencia que sus compañeros más hábiles.

En el estudio IV se explora el rol de la coherencia del orden de lectura y la familiaridad del texto en las

Justificación y objetivos

estrategias de procesamiento de los mapas de contenidos. A partir de la evidencia descrita anteriormente, se predice que los lectores reprocesarán los mapas con mayor frecuencia y por mayor tiempo cuando la coherencia del texto (Rink et al., 2003; Vauras et al., 1992) o la familiaridad con el mismo (Kaakinen et al., 2003; Soederberg Miller & Stine-Morrow, 1998; Wiley & Rayner, 2000), sean bajas.

2.4. EFECTOS DIFERENCIALES EN LA REPRESENTACIÓN MENTAL DEL TEXTO DEBIDOS A LA SELECCIÓN DE SECCIONES Y DEL ORDEN DE LECTURA

En la investigación previa no se han diferenciado los efectos en la representación mental del texto debido a las estrategias de selección de nodos para la lectura y selección del orden de lectura. La evidencia empírica existente nos permite predecir que la selección del orden de lectura afecta principalmente a la construcción del modelo de la situación (Foltz, 1996), mientras que la elección de secciones podría influir esencialmente en la base del texto (Lawless & Kulikowich, 1996). Esta hipótesis se explora directamente en el estudio I (Exp. 1), en el que los participantes pueden variar tanto en el orden de lectura seguido como en el número de secciones accedidas. Esta predicción se complementa con los experimentos conducidos en los estudios II y III, en los que el orden de lectura varía, pero el número de secciones accedidas se mantiene constante.

2.5. ¿PUEDE EL ESTUDIO DE LAS ESTRATEGIAS DE LECTURA AYUDAR A CLARIFICAR LA INVESTIGACIÓN SOBRE LA COMPRENSIÓN EN HIPERTEXTO?

La investigación previa ha estudiado las estrategias de lectura en hipertexto de forma aislada, como se comentó anteriormente. Sin embargo, hasta el momento no se ha estudiado el papel que podrían tener las estrategias a la hora de explicar los resultados inconsistentes en la literatura (e.g. Unz & Hesse, 1999).

En un experimento en el que se manipule el tipo de mapa de contenidos (e.g. jerárquico vs. en red), los resultados podrían variar dependiendo del tipo de estrategias que llevaran a cabo los participantes en cada uno de los grupos experimentales. En este sentido, en el experimento previamente descrito de Foltz (1996), dos grupos de participantes leyeron un mismo texto en formato hipertexto simple o en formato hipertexto adaptativo, que presentaba información extra para la comprensión de los contenidos de una sección cuando el participante realizaba una transición entre secciones poco coherente. Contrariamente a lo esperado, no se encontraron diferencias en la comprensión para ambos formatos. Este resultado podría explicarse debido al hecho de que ambos grupos siguieron estrategias de lectura similares (Foltz, 1996, p. 128).

Un objetivo tangencial del presente trabajo es comprobar si el análisis de las estrategias de lectura en hipertexto puede ayudar a clarificar efectos de manipulaciones experimentales del hipertexto (e.g. tipo de mapas de contenidos, coherencia del texto), para los que hasta el momento existe evidencia heterogénea. En el estudio I (Exp 2.) se analiza el papel de las estrategias de selección del orden de lectura para explicar el procesamiento de mapas de contenidos coherentes o poco coherentes, mientras que en el estudio IV se exploran las estrategias de procesamiento de mapas de contenido para explicar las diferencias debidas tanto a la familiaridad del texto como a la coherencia del mismo. En ambos casos, se espera que un análisis global no muestre diferencias en comprensión para las manipulaciones experimentales (e.g. tipo de mapa de contenidos), pero que estas sí se encuentren una vez controlada la influencia de las estrategias de lectura.

3. DISCUSIÓN

3.1. EFECTOS DE LA ELECCIÓN DEL ORDEN DE LECTURA EN LA COMPRESION

3.1.1. IDENTIFICACIÓN DE ESTRATEGIAS PARA LA ELECCIÓN DEL ORDEN DE LECTURA

El estudio II ha permitido identificar tres estrategias utilizadas por los lectores para seleccionar el orden de lectura, a partir de sus propias respuestas. Los lectores pueden elegir el orden basándose en las relaciones semánticas entre secciones (estrategia de coherencia; Foltz, 1996), en base al interés suscitado por una sección (estrategia de interés, Ainley et al., 2001) o en relación a la posición del enlace en la pantalla (estrategia de la posición en pantalla). Estos resultados cuestionan el modelo de la competición estratégica (Goldman & Saul, 1990), cuando postula que los lectores se mueven por el texto principalmente para intentar mantener la coherencia de su representación mental. Los resultados suscitan la pregunta sobre qué factores hacen que el lector se decante por una estrategia u otra. Como se verá más adelante, estudios sucesivos trataron de responder de manera inicial a esta pregunta.

3.1.2. EFECTOS ESTRATÉGICOS E INDUCIDOS POR EL TEXTO

3.1.2.1. Lectores con bajo conocimiento previo

La distinción entre los efectos estratégicos e inducidos por el texto en el proceso de elección del orden de lectura permitió clarificar la naturaleza de los procesos de comprensión en esta tarea. Los lectores poco familiarizados con la materia adquirieron un mejor modelo de la situación del texto al seguir una estrategia de coherencia. Este resultado se encontró cuando los participantes podían utilizar un mapa de contenidos para guiar su orden de lectura (estudio I, exp 1), cuando la elección del orden solamente se podía basar en el análisis de los enlaces (estudio II, exp 1; estudio III), así como cuando fueron instruidos a seguir dicha estrategia (estudio II, exp 2). Este aprendizaje fue similar al que obtuvieron al leer el mismo texto en un orden coherente, sin que pudieran elegir el orden de lectura (estudio II, exp. 2). Igualmente, los participantes que siguieron una estrategia de interés o de posición en pantalla comprendieron el texto de forma similar a los que simplemente leyeron el mismo texto en un orden incoherente sin elegir el orden de lectura. En conjunto, estos resultados sugieren que el lector con bajo conocimiento previo se limita a construir su representación del texto procesando la información entre secciones leídas secuencialmente, sin que existan procesos asociados directamente a la estrategia elegida. Cuando las dos secciones guardan una fuerte relación semántica, el proceso de construcción de la representación es fluido, mientras que cuando las secciones no están relacionadas, se produce un corte en la coherencia del texto que conlleva una peor comprensión del texto (e.g. Budd et al., 1995).

3.1.2.2. Lectores con alto conocimiento previo

Los lectores más familiarizados con la temática, por su parte, comprendieron el texto de forma similar independientemente de la estrategia seguida. Los procesos que les condujeron a este aprendizaje fueron, sin embargo, diferentes para cada estrategia. Por un lado, los resultados sugieren que aquellos que siguieron (estudio II, exp. 1; estudio III) o fueron instruidos a seguir (estudio II, exp. 2) una estrategia de coherencia procesaron el texto activamente para establecer las relaciones semánticas entre secciones, lo que se tradujo en un alto nivel de aprendizaje (E. Kintsch & W. Kintsch, 1995; McNamara, 2001). La coherencia del orden de lectura no facilitó la comprensión, como se comprobó en un grupo de participantes familiarizados con la materia que leyeron un texto coherente sin poder elegir el orden de

Conclusiones

lectura (estudio II, exp. 2). En ese caso, la comprensión del texto empeoró, probablemente debido a que los lectores se implicaron en un procesamiento superficial del texto inducido por la alta coherencia del orden de lectura (Schnotz, 1982; cf. McNamara & Kintsch, 1996; McNamara et al., 1996).

Por otro lado, en el caso de los lectores con conocimiento previo que siguieron (estudio II, exp. 1; estudio III) o fueron instruidos a seguir (estudio II, exp. 2) la estrategia de interés, los datos no permiten diferenciar claramente entre los efectos estratégicos de los inducidos por el texto. Estos participantes comprendieron al mismo nivel que aquellos que leyeron sin elegir el orden de lectura el mismo texto ordenado de forma poco coherente (i.e. un orden similar al obtenido tras seguir la estrategia de interés). Este resultado sugiere que los lectores procesaron activamente el texto inducidos básicamente por la baja coherencia del orden de lectura (Schnotz, 1982). Una explicación complementaria sería que el interés situacional generado por esta estrategia podría haber aportado recursos atencionales automáticos a la tarea de lectura (e.g. McDaniel et al., 2000), posibilitando una mejor comprensión del texto a los lectores con cierto conocimiento previo de la materia (Alexander et al., 1995; Garner & Gillingham, 1991). El procedimiento utilizado no permite separar la contribución de ambos factores, aunque es posible concluir que los lectores familiarizados con la temática que utilizan la estrategia de interés para determinar el orden de lectura procesan el texto activamente.

Por último, los participantes que siguieron la estrategia de la posición en la pantalla vieron facilitada su comprensión por el orden de lectura poco coherente inducido por dicha estrategia (estudio II, exp. 1; estudio III) (Schnotz, 1982). La comprensión de este grupo fue similar a la obtenida por el grupo control que leyó el texto prefijado en un orden poco coherente (estudio II, exp. 2), por lo que como era previsible no se encontraron efectos estratégicos asociados a dicha estrategia. En conclusión, los resultados para los participantes familiarizados con la materia sugieren que un aspecto crítico para la construcción de una representación del texto coherente es que el lector procese el texto activamente, mediante la activación de su conocimiento previo (Kintsch, 1994). Esta activación puede venir inducida tanto por la propia estrategia seguida (estrategia de coherencia o interés), como por el texto en sí (baja coherencia textual).

3.2. EFECTOS DEL PROCESAMIENTO DE LOS MAPAS DE CONTENIDO EN LA COMPRENSIÓN

En el estudio IV se relacionaron las estrategias de procesamiento de los mapas de contenido (medidas a través de los movimientos oculares durante la lectura), con la comprensión final del texto (medida mediante preguntas abiertas). Los participantes leyeron una serie de textos con cuyas temáticas estaban más o menos familiarizados, y cuyos párrafos se presentaban en un orden más o menos coherente. Como se hipotetizó, las estrategias de procesamiento no predijeron la comprensión de textos ordenados de manera coherente (Mayer, 1978). Sin embargo, para los textos menos coherentes las estrategias de procesamiento de los mapas sí predijeron parte de la comprensión de los textos. Además, esta predicción difirió para los textos más o menos familiares. Para los textos menos familiares, sólo el tiempo de relectura de los mapas de contenido predijo mediante una función positiva la comprensión de preguntas abiertas basadas en el texto. Los datos sugieren que aquellos lectores poco familiarizados que reprocesaron por más tiempo los mapas adquirieron mejor la estructura de los textos, que pudo servir de base para su representación mental del texto (Goldman, 1996). Por el contrario, para los textos más familiares, la relación entre reprocesamiento del mapa y comprensión medida a partir de preguntas abiertas basadas en el texto fue negativa: cuanto mayor tiempo releían los mapas, menor fue el aprendizaje. Este efecto podría indicar que la mayor relectura de los mapas previno a los lectores familiarizados con la materia de activar su conocimiento previo para generar la representación del texto (Shapiro, 1998). Como en el caso de las estrategias para la selección del orden de lectura, los factores que facilitan el

Conclusiones

procesamiento del hipertexto a los lectores con bajo conocimiento previo (e.g. orden de lectura coherente, mapa de contenidos), inducen al lector con conocimiento previo a procesar el texto de forma superficial (McNamara, 2001; McNamara et al., 1996; McNamara & Kintsch, 1996; Schnotz, 1982).

Los resultados mostraron un efecto inesperado. Los lectores de textos familiares ordenados de forma coherente que reprocesaron por mayor tiempo los mapas, aprendieron menos que aquellos que no los reprocesaron tanto, según los resultados en las preguntas de inferencia. Dos explicaciones pueden considerarse para interpretar este efecto inesperado. Primero, el efecto podría deberse a una falta de activación del conocimiento previo de los lectores, como se consideró para los textos familiares y poco coherentes. La lectura de un texto familiar y ordenado de manera coherente no induce de por sí una activación del conocimiento existente (McNamara et al., 1996; McNamara & Kintsch, 1996; Schnotz, 1982). Es decir, tanto si los participantes se focalizaron en el texto (i.e. menos reprocesamiento de los mapas) como si reprocesaron por más tiempo los mapas, la activación de su conocimiento no debería ser elevada (al menos al nivel que se daría cuando leyeron un texto familiar ordenado de forma poco coherente). Las diferencias en la comprensión observadas no pudieron deberse a una disparidad en la activación del conocimiento previo. Una segunda explicación podría centrarse en el reprocesamiento como señal de mala comprensión del texto. En otras palabras, los participantes que reprocesaron por más tiempo los mapas de textos familiares y ordenados de forma coherente, podrían haber experimentado problemas para comprender el texto, y por ese motivo habrían reprocesado los mapas. En este sentido, hay que señalar que este efecto sólo se da para las preguntas de inferencia, que intentan evaluar la comprensión al nivel del modelo de la situación. Investigación previa ha revelado que los lectores se centran fundamentalmente en ese nivel de la comprensión para monitorizar su comprensión durante la lectura, y no en la representación de la base del texto, evaluada por las preguntas basadas en él (Rawson, Dunlosky, & Thiede, 2000).

Dada la naturaleza correlacional de los análisis del estudio IV que relacionan estrategias de procesamiento y comprensión, esta interpretación debería corroborarse con otros métodos experimentales, mediante la combinación del análisis de los movimientos oculares y la técnica del pensamiento en voz alta (Kaakinen & Hyönä, 2005). Si la interpretación del “fallo de comprensión” fuera correcta, los lectores de textos familiares ordenados de forma coherente que reprocesaran por mayor tiempo los mapas, deberían expresar mayor número de problemas asociados a la comprensión en los protocolos verbales.

3.3. FACTORES DETERMINANTES DE LA ELECCIÓN DE ESTRATEGIAS DE LECTURA

3.3.1. DETERMINANTES DE LA ELECCIÓN DE ESTRATEGIAS PARA LA ELECCIÓN DEL ORDEN DE LECTURA

El estudio III constituye una primera aproximación al estudio de los mecanismos implicados en la elección de estrategias para la elección del orden de lectura en hipertexto. Concretamente, las habilidades de metacompreensión demostraron ser un factor relevante para esta tarea (Roberts & Newton, 2001), en conjunción con el conocimiento previo del lector (Borkowski et al., 1987; O'Really & McNamara, 2002). Los lectores novatos en la materia seleccionaron mayor número de secciones basándose en la estrategia de coherencia cuando poseían habilidades de metacompreensión altas. Sin embargo, cuando sus habilidades de metacompreensión eran bajas, los participantes sin conocimiento previo tendían a seleccionar el orden de lectura de acuerdo a las estrategias de interés y posición en la pantalla. Como se había encontrado en el estudio anterior, los participantes que siguieron fundamentalmente estas dos estrategias construyeron un peor modelo de la situación que los que siguieron la estrategia de coherencia. Globalmente, los resultados sugieren que la habilidad de los participantes para monitorizar adecuadamente su progresión en la

Conclusiones

comprensión del texto les previno de utilizar sistemáticamente estrategias perjudiciales para el aprendizaje (i.e. estrategias de interés y de posición en la pantalla).

3.3.2. DETERMINANTES DE LA ELECCIÓN DE ESTRATEGIAS PARA EL PROCESAMIENTO DE MAPAS DE CONTENIDO

El estudio IV permite identificar diversos factores relacionados con la puesta en marcha de estrategias para la exploración de los mapas de contenido. Los participantes exploraron los mapas de contenido por más tiempo cuando estaban poco familiarizados con la materia (tanto procesamiento como reprocesamiento), así como cuando el texto estaba ordenado de forma poco coherente (mayor reprocesamiento). Estos resultados complementan los efectos encontrados en la lectura de textos lineales (Kaakinen et al., 2003; Soederberg Miller & Stine-Morrow, 1998; Wiley & Rayner, 2000, para el efecto de familiaridad; Rink et al., 2003, Vauras et al., 1992, para el efecto de coherencia). En ambos casos, el procesamiento del mapa de contenidos podría guardar una relación estrecha con los problemas en la construcción de la representación del texto asociados a la poca familiaridad o baja coherencia del texto.

Los resultados mostraron que el tipo de mapa utilizado en el estudio IV se procesa principalmente al comienzo de la lectura. De hecho, durante la lectura de la primera y segunda sección de los textos (de cinco secciones), los participantes procesaron por más tiempo los mapas que el propio texto, cuando éste era poco familiar, y distribuían igualmente su tiempo de procesamiento entre los mapas y el texto cuando éste era familiar. Más adelante, durante la tercera a quinta sección de los textos, el tiempo de procesamiento para los mapas disminuyó drásticamente. Este efecto es consistente con la Teoría de la Asimilación de Mayer (1979), que propone que los lectores usan los mapas de contenidos en el momento de la codificación de la información para establecer un esquema del contenido del texto en sí. Asimismo, los datos revelaron dos interacciones entre familiaridad y coherencia del texto, para los datos de primera y segundo procesamiento. Los resultados sugieren que cuando los lectores se encontraron con problemas en la coherencia de tipo estructural, pusieron en marcha estrategias para solventar dichos problemas como el aumento de tiempo de procesamiento de los mapas (Roberts & Newton, 2001). Este proceso se dio en diferentes momentos dependiendo de la familiaridad con el texto. Inmediatamente después de iniciar la lectura de un nuevo texto, los participantes de temas familiares fueron capaces de identificar que el texto estaba ordenado de forma incoherente, y por tanto procesaron los contenidos por más tiempo. Por el contrario, los lectores de textos poco familiares necesitaron más tiempo para identificar los textos ordenados de manera poco coherente, por lo que dedicaron mayor tiempo a procesar los contenidos después de un primer procesamiento de los mismos (i.e. fijaciones de segunda-pasada).

3.4. EFECTOS DIFERENCIALES EN LA REPRESENTACIÓN MENTAL DEL TEXTO DEBIDOS A LA SELECCIÓN DE SECCIONES Y DEL ORDEN DE LECTURA

El estudio I (Exp. 1) permitió diferenciar los efectos de la elección de secciones y del orden de lectura, en la base del texto y en el modelo de la situación respectivamente. Como se predijo, se encontró una relación directa entre el número de secciones leídas por los participantes y la comprensión a nivel de la representación de la base del texto (medida a través de las preguntas basada en el texto), pero no a nivel del modelo de la situación (medido a partir de las preguntas de inferencia y la tarea de claves asociadas). Este efecto se encontró para los participantes con bajo conocimiento previo; los lectores expertos, por su parte, podrían haber utilizado su conocimiento previo para rellenar las partes de la base del texto correspondientes a las partes no leídas. Conjuntamente, en este experimento se constató que el orden de lectura influyó fundamentalmente la construcción del modelo de la situación. De hecho, cuando dos

Conclusiones

grupos de participantes leyeron el mismo número de secciones pero difirieron en el orden de lectura (grupos 1 y 2 del estudio I, exp. 1), mostraron diferencias en su representación del modelo de la situación pero no de la base del texto. El efecto del orden de lectura estaba relacionado con la coherencia semántica del mismo: a mayor coherencia mayor aprendizaje.

Ambos efectos se complementan con los resultados de los estudios II y III descritos previamente. Como ya se discutió anteriormente, los lectores con bajo conocimiento previo que siguieron órdenes diferentes de lectura difirieron en su comprensión a nivel del modelo de la situación. En el estudio II (Exp. 1 y 2) no se encontraron diferencias en la comprensión a nivel de la base del texto, un resultado esperado debido a que en ambos experimentos los participantes eran instruidos a leer todas las secciones del hipertexto. Sin embargo, el estudio III sí mostró diferencias en este nivel de comprensión pese a que los lectores también leyeron todas las secciones del hipertexto. Los participantes que siguieron la estrategia de coherencia construyeron una mejor base del texto que aquellos que siguieron las estrategias de interés o de posición en la pantalla. Un análisis minucioso de este resultado aparentemente contradictorio nos permite sin embargo ahondar en la relación entre estrategias de lectura y la construcción de la base del texto. Concretamente, las diferencias observadas podrían ser debidas al procedimiento utilizado en ambos experimentos (estudio II, exp. 1, y estudio III). En el primero de los experimentos, los participantes seleccionaban la sección siguiente inmediatamente después de acabar de leer una sección concreta. Sin embargo, en el segundo de los experimentos los participantes realizaron una tarea para evaluar sus habilidades de metacompreensión entre la finalización de la lectura de una sección y la presentación de la siguiente. Este impasse, que de media duró 5.13 segundos, podría haber interferido en la construcción de una representación de la base del texto coherente, para lo cual los lectores deben relacionar las proposiciones importantes de una sección, con aquellas de la siguiente sección leída (e.g. Budd et al., 1995). En este mismo sentido trabajos anteriores han revelado que las interrupciones durante la lectura pueden interferir en la comprensión (Glanzer, Dorfman, & Kaplan, 1981; Glanzer, Fischer, & Dorfman, 1984; Lorch, 1993). En el segundo de los experimentos, los participantes que siguieron las estrategias de interés y de posición en la pantalla se vieron afectados por la tarea intermedia más que aquellos que siguieron la estrategia de coherencia, probablemente porque tras la interrupción debían reactivar las proposiciones de la sección anterior que en la mayoría de los casos estaban poco relacionadas con la siguiente sección (Levy et al., 1995).

3.5. ESTRATEGIAS DE LECTURA E INVESTIGACIÓN EN HIPERTEXTO

Cuando estudiamos el efecto de diferentes características del hipertexto en la comprensión, los resultados no mostraron efectos principales de la manipulación experimental. En el estudio I (Exp. 2), se comparó la comprensión de participantes con bajo y alto conocimiento previo que leyeron un hipertexto a partir de un mapa de contenidos organizado con menos o más coherencia entre secciones. Un análisis general considerando únicamente el tipo de mapa y el conocimiento previo no mostró diferencias entre grupos para las variables de comprensión estudiadas. Solamente tras considerar el papel de las estrategias para la selección del orden de lectura se encontraron diferencias entre grupos. Concretamente, tras reagrupar a los participantes de acuerdo a la coherencia semántica del orden de lectura seguido, se observó que los que tenían un bajo conocimiento previo comprendían mejor el texto cuando seguían un orden de lectura coherente, mientras que aquellos familiarizados con la temática comprendían mejor cuando seguían un orden de lectura poco coherente.

En el estudio IV se manipuló el papel de la coherencia del orden del texto y la familiaridad con el mismo, para observar sus efectos en la comprensión. Los participantes disponían en todo momento de un mapa de contenidos que mostraba la estructura jerárquica de los contenidos. El análisis de ambos factores no reveló diferencias para las medidas

Conclusiones

de comprensión utilizadas. Pero tras considerar las estrategias que los participantes utilizaron para procesar el mapa de contenidos, los resultados mostraron diferencias entre grupos. Los participantes de textos poco familiares y poco coherentes aprendían más cuando reprocesaban el mapa de contenidos por más tiempo, mientras que los participantes de textos familiares y poco coherentes comprendían mejor cuando reprocesaban el mapa por menos tiempo. Ambos efectos encontrados en los estudios I y IV se pueden explicar a partir de los procesos de comprensión utilizados en la lectura en hipertexto, como se ha discutido en los apartados anteriores. En este punto dichos efectos sirven para ejemplificar el problema de no considerar las estrategias de lectura que utilizan los lectores de hipertexto, a la hora de estudiar el papel de diversos aspectos de este formato (e.g. tipo de mapa de contenidos, coherencia del orden) en la comprensión. Por tanto, es posible concluir que al menos parte de los resultados contradictorios en la literatura sobre comprensión en hipertexto (Dillon & Gabbard, 1998; Unz & Hesse, 1999), se podrían deber al hecho de que en dichos experimentos no se consideró el efecto mediador de las estrategias de lectura.

4. CONCLUSIONES

4.1. ESTRATEGIAS DE LECTURA Y COMPRENSIÓN EN HIPERTEXTO

En la presente tesis doctoral se han identificado diferentes estrategias de comprensión que los lectores de hipertextos utilizan tanto para decidir el orden de lectura como para adquirir la estructura del texto a partir de mapas de contenidos. Los lectores de hipertexto deciden su orden de lectura en base a la relación semántica entre secciones (Foltz, 1996), al interés suscitado por los enlaces (Ainley et al., 2001), o en base a una posición en la pantalla. Los lectores llevan a cabo estrategias de procesamiento de mapas de contenidos que varían fundamentalmente en el tiempo de relectura de los mismos. Dichas estrategias influyen selectivamente en el aprendizaje de los lectores, dependiendo de ciertas variables como el conocimiento previo o la coherencia del texto.

También se identificaron diversos factores responsables de la puesta en marcha de dichas estrategias, como las habilidades de metacomprensión, la familiaridad y la coherencia del texto. En general, dichos factores apuntan a que el lector de hipertexto ejecuta estrategias para optimizar su aprendizaje cuando encuentra un problema al comprender el texto (cf. Rink et al., 2001). Pero si su habilidad para evaluar su comprensión es baja, podría pasar por alto dichos problemas y poner en marcha estrategias menos óptimas. En cualquier caso, el presente trabajo constituye tan sólo un primer paso en el estudio de los mecanismos determinantes de la elección de estrategias de comprensión. Tradicionalmente, los modelos de comprensión evitan entrar en esta discusión, ya que promulgan teorías generales sobre microprocesos que minimizan las decisiones por parte de los lectores. Dilucidar la causa última por la cual los lectores utilizan una u otra estrategia requerirá futuros desarrollos teóricos y empíricos (Brown, 1987; Roberts & Newton, 2001).

Por último, el presente trabajo también permite clarificar los mecanismos de la construcción de una representación mental coherente en hipertexto. Globalmente, los resultados sugieren que los lectores con bajo conocimiento previo en una materia generan la representación enlazando las proposiciones de secciones leídas consecutivamente. Este proceso se verá interferido en la medida en que dichas secciones no estén relacionadas semánticamente (e.g. Budd et al., 1995), o si entre la lectura de ambas secciones se introdujera una tarea intermedia (e.g. Glanzer et al., 1981; Glanzer et al., 1984; Lorch, 1993), sobretodo si esta interrupción se produce entre secciones poco relacionadas (Levy et al., 1995). Para los lectores con cierto conocimiento previo un factor adicional importante es la activación de su conocimiento previo (Kintsch, 1994). El grado de activación de su conocimiento determinará la coherencia de la representación mental generada. Esta activación puede estar inducida por componentes estratégicos (análisis semántico de las relaciones entre secciones), o por elementos del texto (orden de lectura poco coherente).

4.2. MEJORA DE LA COMPRENSIÓN EN HIPERTEXTO

Los resultados encontrados en el presente trabajo de investigación también podrían servir de base para futuros desarrollos de hipertextos educativos. Un efecto relevante para el aprendizaje encontrado en varios de nuestros estudios consiste en que los lectores con bajo conocimiento previo generan una mejor comprensión del texto al leer un texto ordenado de forma coherente (Foltz, 1996). Este beneficio es similar cuando el lector elige seguir un orden coherente (o es instruido a seguirlo), y cuando el lector lee un texto en orden coherente sin elegir el orden de lectura (estudio II, exp. 2). Partiendo de este resultado, los hipertextos educativos podrían facilitar la comprensión de los textos induciendo un orden de lectura coherente. Esta posibilidad se puede implementar en el marco de los hipertextos adaptativos, que permiten al diseñador decidir qué enlaces estarán presentes en cada sección (Brusilovsky, 2004). Los enlaces podrían

Conclusiones

habilitarse o deshabilitarse, dependiendo del grado de coherencia semántica entre secciones. Por ejemplo, a partir de la metáfora del semáforo, una “luz verde” podría colocarse al lado de los enlaces que llevaran a secciones con alta coherencia semántica, y una “luz roja” indicaría aquellos enlaces que llevaran a una sección menos relacionada. En ese sentido, la “metáfora del semáforo” serviría para sugerir órdenes de lectura más adecuados (Brusilovsky & Eklund, 1998).

Un segundo efecto relacionado con el aprendizaje relacionó las habilidades de metacompreensión con la elección de estrategias óptimas para la selección del orden de lectura (estudio III). Cuando mejores son estas habilidades, mejor es la estrategia seguida. Por tanto, para inducir a los lectores a seguir un orden de lectura coherente los hipertextos educativos podrían incluir herramientas para inducir una mejor metacompreensión del texto (Azevedo & Cromley, 2004; Azevedo, Guthrie & Seibert, 2004; Bannert, 2003, 2004; Jacobson, Maouri, Mishra & Kolar, 1996; Lin & Lehman, 1999; Puntambekar & Stylianou, 2005; Schmidt & Ford, 2003; Stadler & Bromme, 2004, 2005). Por ejemplo, Puntambekar y Stylianou (2005) describen un hipertexto educativo en el que el orden de lectura seguido por el lector es examinado on-line. Este orden es analizado entre otras cosas en términos de número de transiciones entre temas relacionados. Cuando el sistema detecta que el lector realiza transiciones entre secciones poco relacionadas, le envía mensajes animándole a que evalúe su comprensión (e.g. “Piensa si realmente estás entendiendo el texto de acuerdo a tus objetivos”), o a que elija un orden de lectura más coherente (e.g. “Recuerda que puedes utilizar el mapa de contenidos para acceder a las secciones”). Los autores desarrollaron un experimento en el que un grupo de lectores utilizó el hipertexto con los mensajes, y otro servía de grupo control. Apoyando la utilidad de este tipo de herramientas, el grupo que utilizó el hipertexto con los mensajes superó al grupo control en una serie de tareas de comprensión estructural.

5. REFERENCIAS

Referencias

- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 545-561.
- Alexander, P. A., Jetton, T. L. & Kulikowich, J. M. (1995). Interrelationship of knowledge, interest, and recall: assessing a model of domain learning. *Journal of Educational Psychology, 87*, 559-575.
- Anderson-Inman, L., & Horney, M. A. (1994). The electrotext project: Hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia, 3*, 71-91.
- Azevedo, R. & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*, 523-535.
- Azevedo, R., Guthrie, J. T., Seibert, D. (2004). The role of self-regulated learning in fostering students' conceptual understanding of complex systems with hypermedia. *Journal of Educational Computing Research, 30*, 87-111.
- Baddeley, A. D. (1986). *Working memory*. New York, NY: Clarendon Press/Oxford University Press.
- Baddeley, A. D. (2003). Working memory and language: an overview. *Journal of Communication Disorders, 36*, 189-208.
- Bannert, M. (2003). Effekte metakognitiver lernhilfen auf den wissenserwerb in vernetzten lernumgebungen [Effects of metacognitive help on knowledge acquisition in web-based learning environments]. *Zeitschrift für Pädagogische Psychologie, 17*, 1, 13-25.
- Bannert, M. (2004). Designing metacognitive support for hypermedia learning. In H. Niegemann, D. Leutner & R. Brünken (Eds.). *Instructional Design for Multimedia-Learning* (pp.19-30). Münster, Germany: Waxmann.
- Barab, S. A., Bowdish, B. E., & Lawless, K. A. (1997). Hypermedia navigation: profiles of hypermedia users. *Educational Technology Research and Development, 45*, 23-42.
- Barab, S. A., Bowdish, B. E., Young, M. F., & Owen, S. V. (1996). Understanding kiosk navigation: using log files to capture hypermedia searches. *Instructional Science, 24*, 377-395.
- Barab, S. A., Fajen, B. R., Kulikowich, J. M. & Young, M. F. (1996). Assessing hypertext navigation through Pathfinder: prospects and limitations. *Journal of Educational Computing Research, 15*, 185-205.
- Barab, S. A., Young, M. F., & Wang, J. (1999). The effects of navigational and generative activities in hypertext learning on problem solving and comprehension. *International Journal of Instructional Media, 26*, 283-309.
- Borkowski, J., Carr, M., & Pressely, M. (1987). "Spontaneous" strategy use: perspectives from metacognitive theory. *Intelligence, 11*, 61-75.
- Britt, M.A., Rouet, J.-F., & Perfetti, C.A. (1996). Using hypertext to study and reason about historical evidence. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 43-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Britton, B. K. (1994). Understanding expository text: building mental structures to induce insights. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 641-674). San Diego: Academic Press.
- Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Brusilovsky, P. (2004). Adaptive navigation support: from adaptive hypermedia to the adaptive web and beyond. *PsychNology Journal, 2*, 7-23.
- Brusilovsky, P., & Eklund, J. (1998). A study of user model based link annotation in educational hypermedia.

Referencias

Journal of Universal Computer Science, 4, 428–448.

Budd, D., Whitney, P., & Turley, K. J. (1995). Individual differences in working memory strategies for reading expository text. *Memory & Cognition*, 23, 735-748.

Chen, C. & Rada, R. (1996). Interacting with hypertext: a meta-analysis of experimental studies. *Human-Computer Interaction*, 11, 125-156.

Coiro, J., & Dobler, E. (in press). Reading comprehension on the Internet: Exploring the online comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*.

Danner, F. W. (1976). Children's understanding of intersentence organization in the recall of short descriptive passages. *Journal of Educational Psychology*, 68, 174-183

Delany, P., & Landow, G. (Eds) (1991). *Hypertext and literary studies*. Cambridge: MIT Press.

DeStefano, D. & LeFevre, J-A. (in press). Cognitive load in hypertext reading: A review. *Computers and Human Behavior*.

Dillon, A. (1996). Myths, misconceptions and an alternative conception on information usage and the electronic medium. In J.-F. Rouet, J.J. Levonen, A.P. Dillon, and R.J. Spiro (Eds.), *Hypertext and Cognition* (pp. 25-42). Mahwah, NJ: Lawrence Erlbaum Associates.

Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, 68, 322-349.

Dunning, D., Jonson, K., Ehrlinger, J., & Kruger, J. (2003). Why people fail to recognize their own incompetence. *Current Directions In Psychological Science*, 12, 83-87.

Fiderio, J. (1988). A grand vision. *Byte*, 13, 237–242.

Foltz, P. W. (1996). Comprehension, coherence, and strategies in hypertext and linear text. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 109-136). Mahwah, NJ: Lawrence Erlbaum Associates.

Garner, R., & Gillingham, M. (1991). Topic knowledge, cognitive interest, and text recall: a microanalysis. *Journal of Experimental Education*, 59, 310-319.

Garner, R., Alexander, P. A., Slater, W., Hare, V.C., Smith, T., & Reis, R. (1986). Children's knowledge of structural properties of expository text. *Journal of Educational Psychology*, 78, 411-416.

Gernsbacher, M. A. (1990). *Language comprehension as structure building*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Gernsbacher, M. A. (1997). Two decades of structure building. *Discourse Processes*, 23, 265-304.

Glanzer, M., Dorfman, D., & Kaplan, B. (1981). Short-term storage in the processing of text. *Journal of Verbal Learning and Verbal Behavior*, 20, 656–670.

Glanzer, M., Fischer, B., & Dorfman, D. (1984). Short-term storage in reading. *Journal of Verbal Learning and Verbal Behavior*, 23, 467–486.

Goldman, S. R. (1996). Reading, writing, and learning in hypermedia environments. In H. van Oostendorp & S. de Mul (Eds.), *Cognitive aspects of electronic text processing* (pp. 7-42). Norwood, NJ: Ablex.

Goldman, S. R., & Saul, E. (1990). Flexibility in text processing: a strategy competition model. *Learning and Individual Differences*, 2, 181-219.

Goldman, S. R., & Varma, S. (1995). CAPping the Construction-Integration model of discourse comprehension. In C. A. Weaver, S. Mannes, & C. R. Fletcher (Eds.), *Discourse comprehension: Essays in honor of Walter Kintsch* (pp. 337–358). Hillsdale, NJ: Erlbaum.

Referencias

- Goldman, S. R., Saul, E., & Coté, N. (1995). Paragraphing, reader, and task effects on discourse comprehension. *Discourse Processes, 20*, 273-305.
- Haberlandt, K. (1980). Story grammar and reading time of story constituents. *Poetics, 9*, 99-116.
- Haberlandt, K., Berian, C., & Sandson, J. (1980). The episode schema in story processing. *Journal of Verbal Learning and Verbal Behavior, 19*, 635-650.
- Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research, 60*, 549-571.
- Hidi, S. (1995). A re-examination of the role of attention in learning from text. *Educational Psychology Review, 7*, 323-350.
- Hofmann, T. R. (1989). Paragraphs, & anaphora. *Journal of Pragmatics, 13*, 239-250.
- Horney, M. A., & Anderson-Inman, L. (1994). The electrotext project: hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia, 3*, 71-91.
- Hyönä, J. (1995). An eye movement analysis of topic-shift effect during repeated reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 1365-1373.
- Hyönä, J., Lorch, R. F. & Kaakinen, J. K. (2002). Individual differences in reading to summarize expository text: evidence from eye fixation patterns. *Journal of Educational Psychology, 94*, 44-55.
- Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research, 12*, 301-333.
- Jacobson, M. J., Maouri, C., Mishra, P., & Kolar, C. (1996). Learning with hypertext learning environments: theory, design, and research. *Journal of Educational Multimedia and Hypermedia, 5*, 239 - 281.
- Jonassen, D. (1993). Effects of semantically structured hypertext knowledge bases on users' knowledge structures. In C. McKnight, A. Dillon, & J. Richardson (Eds), *Hypertext: a psychological perspective* (pp. 153-168). New York: Ellis Horwood.
- Kaakinen, J. K. & Hyönä, J. (2005). Perspective effects on expository text comprehension: evidence from think-aloud protocols, eyetracking, and recall. *Discourse Processes, 40*, 239-257.
- Kaakinen, J. K., Hyönä, J. & Keenan, J. M. (2003). How prior knowledge, WMC, and relevance of information affect eye fixations in expository text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 447-457.
- Kieras, D. E. (1981). Component processes in the comprehension of simple prose. *Journal of Verbal Learning and Verbal Behavior, 20*, 1-23.
- Kintsch, E., & Kintsch, W. (1995). Strategies to promote active learning from text: individual differences in background knowledge. *Swiss Journal of Psychology, 54*, 141-151.
- Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review, 95*, 163-182.
- Kintsch, W. (1994). Text comprehension, memory, and learning. *American Psychologist, 49*, 294-303.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.
- Kintsch, W., & Yarbrough, J. C. (1982). The role of rhetorical structure in text comprehension. *Journal of Educational Psychology, 74*, 828-834.
- Landauer, T. K. (1987). Relations between cognitive psychology and computer system design. In J. M. Carroll (Ed.), *Interfacing thought. Cognitive aspects of human-computer interaction* (pp. 1-25). Cambridge: MIT Press.
- Lawless, K. A., & Kulikowich, J. M. (1996). Understanding hypertext navigation through cluster analysis. *Journal of Educational Computing Research, 14*, 385-399.

Referencias

- Lawless, K. A., & Kulikowich, J. M. (1998). Domain knowledge, interest, and hypertext navigation: a study of individual differences. *Journal of Educational Multimedia and Hypermedia*, 7, 51-70.
- Lawless, K. A., Mills, R., & Brown, S. W. (2002). Children's hypermedia navigational strategies. *Journal of Research on Computing in Education*, 34, 274-284.
- Lee, M. J., & Tedder, M. C. (2003). The effects of three different computer texts on readers' recall: based on working memory capacity. *Computers in Human Behavior*, 19, 767-783.
- Levy, B. A., Campsall, J., Browne, J., Cooper, D., Waterhouse, C., & Wilson, C. (1994). Reading fluency: episodic integration across texts. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 1169-1185.
- Lin, X. & Lehman, J. D. (1999). Supporting learning of variable control in a computer-based biology environment: effects of prompting college students to reflect on their own thinking. *Journal of Research in Science Teaching*, 36, 837-858.
- Lodewijks, H. (1982). Self-regulated versus teacher-provided sequencing of information in learning from text. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 509-520). Amsterdam: North-Holland.
- Lorch, R. F. (1993). Integration of topic and subordinate information during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 1071-1081.
- Lorch, R. F., Jr. (1989). Text-signaling devices and their effects on reading and memory processes. *Educational Psychology Review*, 1, 209-234.
- Lorch, R. F., Jr., Lorch E. P., & Matthews, P. D. (1985). On-line processing of the topic structure of a text. *Journal of Memory and Language*, 24, 350-362.
- Lorch, R. F., Jr., Lorch E. P., & Morgan, A. M. (1987). Task effects and individual differences in on-line processing of the topic structure of a text. *Discourse Processes*, 10, 63-80.
- Lowerse, M. (2001). An analytic and cognitive parameterization of coherence relations. *Cognitive Linguistics*, 12, 291-315.
- Mandler, J. M., & Goodman, M. S. (1982). On the psychological validity of story structure. *Journal of Verbal Learning and Verbal Behavior*, 21, 507-523.
- Mayer, R. E. (1976). Some conditions of meaningful learning for computer programming: advance organizers and subject control of frame order. *Journal of Educational Psychology*, 68, 143-150.
- Mayer, R. E. (1978). Advance organizers that compensate for the organization of text. *Journal of Educational Psychology*, 71, 880-886.
- Mayer, R. E. (1979). Twenty years of research on advance organizers: Assimilation theory is still the best predictor of results. *Instructional Science*, 8, 133-167.
- Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction*, 13, 125-139
- McDaniel, M. A., Waddill, P. J., Finstad, K., & Bourg, T. (2000). The effects of text-based interest on attention and recall. *Journal of Educational Psychology*, 92, 492-502.
- McKnight, C; Dillon, A. & Richardson, J. (1993). *Hypertext: a psychological perspective*. New York: Ellis Horwood.
- McKoon, G. & Ratcliff, R. (1992). Inference during reading. *Psychological Review*, 99, 440-466
- McNamara, D. S. (2001). Reading both high-coherence and low-coherence texts: Effects of text sequence and prior knowledge. *Canadian Journal of Experimental Psychology*, 55, 51-62.
- McNamara, D. S., & Kintsch, W. (1996). Learning from text: effect of prior knowledge and text coherence.

Referencias

Discourse Processes, 22, 247-288.

McNamara, D. S., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interaction of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1-42.

Moos, D. C. & Azevedo, R. (2006). The role of goal structure in undergraduates' use of self-regulatory processes in two hypermedia learning tasks. *Journal of Educational Multimedia and Hypermedia*, 15, 49-86

Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, 23, 237-255.

O'Reilly, T., & McNamara, D. S. (2002). What's a science student to do? In W. D. Gray & C. D. Schunn (Eds.), *Proceedings of the Twenty-fourth Annual Meeting of the Cognitive Science Society*, 726-731. Mahwah, NJ: Erlbaum.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds). *Handbook of Self-Regulation* (pp. 451-502). San Diego: Academic Press.

Puntambekar, S., Stylianou, A., & Hübscher, R. (2003). Improving navigation and learning in hypertext environments with navigable concept maps. *Human-Computer Interaction*, 18, 395-428.

Rawson, K. A., Dunlosky, J., & Thiede, K. W. (2000). The rereading effect: Metacomprehension accuracy improves across reading trials. *Memory & Cognition*, 28, 1004-1010.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124, 372-422.

Rink, M., Gámez, E., Díaz, J. M., & de Vega, M. (2003). Processing of temporal information: evidence from eye movements. *Memory & Cognition*, 31, 77-86.

Roberts, M. J., & Newton, E. J. (2001). Understanding strategy selection. *International Journal of Human-Computer Studies*, 54, 137-154.

Rouet, J.-F. & Passerault, J.-M. (1999). Analyzing learner-hypermedia interaction: An overview of online methods. *Instructional Science*, 27, 201-219.

Rouet, J.-L., Favart, M., Britt, M. A. & Perfetti, C. A. (1997). Studying and using multiple documents in history: Effects of discipline expertise. *Cognition & Instruction*, 15, 85-106.

Schmidt, A. M., & Ford, J. K. (2003). Learning within a learner control training environment: The interactive effects of goal orientation and metacognitive instruction on learning outcomes. *Personnel Psychology*, 56, 405-429.

Schnotz, W. (1982). How do different readers learn with different text organizations? In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 87-97). Amsterdam: North-Holland.

Schnotz, W. (1984). Comparative instructional text organization. H. Mandl, N. L. Stein, & T. Trabasso (Eds.), *Learning and comprehension of text* (pp. 53-81). Hillsdale, N. J.: Lawrence Erlbaum Associates.

Schnotz, W. (1993). Adaptive construction of mental representations in understanding expository texts. *Contemporary Educational Psychology*, 18, 114-120.

Schwartz, N. H., Andersen, C., Hong, N., Howard, B. & Mcgee, S. (2004). The influence of metacognitive skills on learners' memory of information in a hypermedia environment. *Journal of Educational Computing Research*, 31, 77-93.

Shapiro, A. M. (1998). Promoting active learning: The role of system structure in learning from hypertext. *Human-Computer Interaction*, 13, 1-35.

Shapiro, A.M., & Niederhauser, D. (2004). Learning from hypertext: research issues and findings. In D.H. Jonassen (Ed), *Handbook of Research on Educational Communications and Technology*, 2nd Ed. (pp 605-620). Mahwah, NJ: Lawrence Erlbaum Associates.

Referencias

- Siegler, R. S. & Jenkins, E. (1989). *How children discover new strategies*. Hillsdale, NJ: Lawrence Erlbaum Associates
- Snapp, J. C., & Glover, J. A. (1990). Advance organizers and study questions. *Journal of Educational Research*, 83, 266-271.
- Soederberg Miller, L. M., & Stine-Morrow, E. A. (1998). Aging and the effects of knowledge on on-line reading strategies. *The Journals of Gerontology*, 53B, 223-233.
- Spiro, R., Coulson, R., Feltovitch, P., & Anderson, D. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In *Proceedings of the Tenth Annual Conference of the Cognitive Science Society* (pp. 375–383). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Spiro, R., Feltovitch, P., Jacobson, M., & Coulson, R. (1992). Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. In T. Duffy & D. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation* (pp. 57–75). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Stadtler, M. & Bromme (2005). Dealing with multiple documents on the WWW: The role of metacognition in the formation of documents models. In B. G. Bara, L. Barsalou, & M. Bucciarelliof (Eds.). *Proceedings of the 27th Annual Conference of the Cognitive Science Society*, (pp. 2068-2073) Mahwah, NJ: Erlbaum.
- Stadtler, M., & Bromme, R. (2004). Laypersons searching the WWW for medical information: The role of metacognition. In K. Forbus, D. Gentner, & T. Reiger (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (p. 1638). Mahwah, NJ: Erlbaum.
- Stiller, K., & Bartsch, M. (2005). Computerbasiertes lernen mit linearem vs. bildbezogenem textabruf und vorwissen [Computer based learning with linear vs. picture oriented access to text and prior knowledge]. *Psychologie in Erziehung und Unterricht*, 52, 210-222.
- Tergan, S.O. (1997). Misleading theoretical assumptions in hypertext/hypermedia research. *Journal of Educational Multimedia and Hypermedia*, 6, 257-284.
- Unz, D. C., & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, 20, 279-295.
- van den Broek, P., Young, M., Tzeng, Y., & Linderholm, T. (1999). The landscape model of reading: inferences and the on-line construction of a memory representation. In H. van Oostendorp & S. R. Goldman (Eds.), *The construction of mental representations during reading* (pp. 71-98). Mahwah, NJ: Lawrence Erlbaum Associates.
- Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.
- Vauras, M., Hyönä, J., & Niemi, P. (1992). Comprehension coherent and incoherent texts: Evidence from eye movement patterns and recall performance. *Journal of Research in Reading*, 15, 39-54.
- Walczyk, J. J. & Taylor, R. W. (1996). How do the efficiencies of reading subcomponents relate to looking back in text? *Journal of Educational Psychology*, 88, 537-545.
- Walczyk, J. J. (1995). Testing a compensatory-encoding model. *Reading Research Quarterly*, 30, 396-408.
- Walczyk, J. J., Marsiglia, C. S., Johns, A. K. & Bryan, K. S. (2004). Children's compensations for poorly automated reading skills. *Discourse Processes*, 37, 47-66.
- Wenger, M. J., & Payne, D. G. (1996). Comprehension and retention of nonlinear text: considerations of working memory and material-appropriate processing. *American Journal of Psychology*, 109, 93–130.
- Wiley, J. & Rayner, K. (2000). Effects of titles on the processing of text and lexically ambiguous words: Evidence from eye movements. *Memory & Cognition*, 28, 1011-1021.
- Zhu, E. (1999). Hypermedia interface design: the effects of number of links and granularity of nodes. *Journal of*

Referencias

Educational Multimedia and Hypermedia, 8, 331–358.

Zwaan, R. A., Magliano, J. P. & Graesser, A. C. (1995). Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 21, 386-397.

APPENDIX I

Salmerón, L., Cañas, J.J., Kintsch, W. & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes*, 40, 171-191.

Abstract

The literature on assessing the cognitive processes involved in hypertext comprehension during the last fifteen years has yielded contradictory results. In this paper we explored a possible factor affecting this situation, mainly the fact that previous works did not control for the potential effects on comprehension of reading strategies in hypertext. In experiment 1, results showed that reading strategies selectively affect the textbase and the situation model level. The number of different nodes read mainly affected the textbase, whereas the reading order influenced the situation model. In experiment 2, the analysis of reading strategies replicated the effect of knowledge and coherence found in the literature on linear text comprehension (McNamara & Kintsch, 1996), but not replicated in hypertext. Low knowledge participants learned more by following a high coherent reading order, whereas high knowledge participants learned more by reading the hypertext in a low coherence order. We discuss the theoretical and methodological consequences of this approach for the study of hypertext comprehension.

Reading Strategies and Hypertext Comprehension

Hypertexts are information systems in which the contents are organized in an interrelated network with the nodes being documents and the links being the relations between these documents. Hypertexts constitute a practical alternative to paper documents in education. Research assessing the cognitive processes involved in hypertext comprehension has grown jointly with the development of these systems in educational fields. However, reviews of the literature published up to 1999 reported few reliable findings about the processes involved in hypertext comprehension (Dillon & Gabbard, 1998; Unz & Hesse, 1999).

In this paper we first describe the results found in the literature on hypertext comprehension since 1999, and conclude that the null and contradictory results of previous work still exist. Second, we propose a theoretical and methodological approach to explore the relation between reading strategies and text comprehension. Third, we describe two experiments designed to evaluate our claims.

Recent research on hypertext comprehension

Most of the research on hypertext comprehension can be framed from the perspective of the Construction-Integration (C-I) model of text comprehension (Van Dijk & Kintsch, 1983; Kintsch, 1988; 1998). The model distinguishes between two of the mental representations that a reader forms from the text: (1) the textbase, a hierarchical propositional representation of the information within the text and (2) the situation model, a representation of what the text is about, that integrates the information with readers' prior knowledge. According to the C-I model, many factors contribute to text comprehension, but prior knowledge and coherence are the main factors. Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text.

In general, readers with high domain knowledge comprehend better at both the textbase and the situation level (Moravcsik & Kintsch, 1993). However, when the analysis takes account of both prior knowledge and text coherence, it has been found that readers with low domain knowledge construct better situation models from a highly coherent text than from an incoherent one, whereas readers with high domain knowledge actually learn more from an incoherent text than from a highly coherent one (McNamara, E. Kintsch, Songer & W. Kintsch, 1996; McNamara & Kintsch, 1996). The explanation for this effect of knowledge and coherence is that naïve readers cannot fill in gaps in the incoherent text without explicit guidance about relationships among information items; on the other hand, expert readers who are overguided will not actively use their own prior knowledge to form the situation model of the text.

These effects have been the starting point of many of the experiments exploring the effects of overviews on hypertext comprehension. Overviews are writing devices that emphasize the contents of a text and their organization (Lorch, 1989). In hypertext, overviews are used as a table of contents that helps the reader to move through the different sections. This is one of the most active areas on hypertext comprehension, and one in which the situation described by Dillon and Gabbard (1998) and Unz and Hesse (1999) become apparent. Starting from research conducted with linear text (e.g. Snapp & Glover, 1990), it has been hypothesized that the overview would act as an "advance organizer," improving readers' memory of the contents. In the experiments reviewed, an overview containing structural information on the contents was compared to an unstructured one (e.g. list of contents, linear version). In most cases, comprehension measures were collected for both the textbase (e.g. recall, text based questions) and for the situation model (e.g. inference questions, essay, cued association, sorting task, concept map). In addition, some of the experiments measured readers' prior knowledge about the subject matter.

However, a review of recent empirical work does not converge on a clear conclusion about the effect of overviews on comprehension (see Table 1). For low knowledge readers, some experiments show that overviews facilitate textbase construction (Moeller & Mueller-Kalthoff, 2000; Potelle & Rouet, 2003), whereas other present null effects (Brinkerhoff, Klein & Koroghlanian, 2001; De Jong & van der Hulst, 2002; Hofman & van Oostendorp, 1999;

Appendix I

Mueller-Kalthoff & Moeller, 2003; Puntambekar, Stylianou & Hübscher, 2003; Shapiro, 1998, 1999) or negative effects (Naumann, Waniek & Krems, 2001; Quathamier & Heineken, 2002). Regarding the situation model construction for low knowledge readers, some experiments show positive effects of an overview (De Jong & van der Hulst, 2002; Potelle & Rouet, 2003; Puntambekar, Stylianou & Hübscher, 2003; Shapiro, 1999, 2000), whereas others present null effects (Moeller & Mueller-Kalthoff, 2000; Mueller-Kalthoff & Moeller, 2003) and negative effects (Hofman & van Oostendorp, 1999; Shapiro, 1998; Waniek, Brunstein, Naumann & Krems, 2003). For high knowledge readers, experiments agree on a null effect of structured overviews in hypertext comprehension both in textbase and situation model construction (Hofman & van Oostendorp, 1999; Moeller & Mueller-Kalthoff, 2000; Mueller-Kalthoff & Moeller, 2003; Potelle & Rouet, 2003; Shapiro, 1999).

These results on hypertext comprehension reveal an unclear situation, just as the earlier results reviewed by Dillon and Gabbard (1998) and Unz and Hesse (1999). The heterogeneity of the results for low knowledge readers regarding both the direction of the effect (positive, null and negative) and the type of comprehension (textbase and situation model) suggest that there is no easy explanation for the contradictory data. Some suggestions for clarifying the state of the art in the field would be to improve the methodological rigor of experiments (e.g. pre-testing of prior knowledge) (Dillon & Gabbard, 1998), to use several measures for text comprehension (Hofman & van Oostendorp, 1999) and to understand the interdependence between navigation behavior and the learning performance (Unz & Hesse, 1999). In the present work we explore the last suggestion, focusing on the role of reading strategies in hypertext comprehension.

Table 1

Reported effects of structured overviews in comprehension, by prior knowledge (low and high) and mental representation (textbase and situation model).

	Low knowledge		High knowledge	
	Textbase	Sit. Model	Textbase	Sit. Model
Brinkerhoff, Klein & Koroghlanian, 2001	=			
De Jong & van der Hulst, 2002	=	+		
Hoffman & van Oostendorp, 1999	= / =	= / - (1)	=	=
Moeller & Mueller-Kalthoff, 2000	+	=	=	=
Mueller-Kalthoff & Moeller, 2003	=	=	=	=
Naumann, Waniek & Krems, 2001	-			
Potelle & Rouet, 2003	= / +	= / + (2)	=	=
Puntambekar, Stylianou & Hübscher, 2003	=	+		
Quathamer & Heineken, 2002	-			
Shapiro, 1998	=	-		
Shapiro, 1999	=	+	=	=
Shapiro, 2000		+		
Waniek et al., 2003		-		

Note. A plus sign means a positive effect of structured overview, a minus sign means a negative effect, and a equals sign means a null effect. (1) Hofman & van Oostendorp (1999) found a null effect for both textbase and situation model questions tapping the macrostructure level (i.e. main ideas), and a negative effect for situation model questions at the microstructure level (i.e. local ideas). (2) Potelle & Rouet (2003) found a positive effect for questions focusing at the macrostructure level and a null effect for questions focusing at the microstructure level.

The role of reading strategies

One variable that might play an important role in comprehension is the reader's strategy. Reading strategies in hypertext can be considered as the decision rule that a reader follows to navigate through the different nodes of a hypertext. For example, readers can read through the contents selecting those nodes that contain interesting information for the reader, or those related to the previous paragraphs read. The relation between strategy use and comprehension have been widely reported on the literature of text comprehension in linear text (Chi, Bassok, Lewis, Reimann & Glases, 1989; Chi, De Leeuw, Chiu & LaVancher, 1994; Goldman & Saul, 1990; Goldman, Saul & Coté, 1995; Magliano, Trabasso & Graesser, 1999; McNamara & Scott, 1999; Pressley, Symons, McDaniel, Snyder & Turnure, 1988; Trabasso & Magliano, 1996; Wagner & Sternberg, 1987). Different reading strategies influence the way readers process the text and hence their text comprehension.

Research on hypertext comprehension has also explored the relation between reading strategies and comprehension (Barab, Bowdish, & Lawless, 1997; Barab, Bowdish, Young, & Owen, 1996; Barab, Fajen, Kulikowich & Young, 1996; Barab, Young & Wang, 1999; Britt, Rouet & Perfetti, 1996; Foltz, 1996; Horney & Anderson-Inman,

Appendix I

1994; Lawless & Kulikowich, 1996, 1998; Lawless, Mills & Brown, 2002; Niederhauser, Reynolds, Salmen & Skolmoski, 2000; Rouet, Favart, Britt & Perfetti, 1997). In most cases, this relation focused on the analysis of the navigational path of the reader. The general approach consists of identifying similar groups of navigational paths using a multidimensional scaling technique, and of analysing possible comprehension differences between groups, as in the studies by Lawless and Kulikowich (1996, 1998). The authors have identified three main navigational groups: knowledge seekers, feature explorers and apathetic hypertext users. Knowledge seekers spend most of the reading time on content related documents, whereas feature explorers do that on the special features of the hypertext (e.g. images, videos, maps). Finally, apathetic users spend short intervals of time on content related documents, and seem to follow a random reading order. Regarding the comprehension outcome for each group, the authors found that knowledge seekers learned more than the other groups. However, other categories have been proposed in the literature based on features of the particular hypertext used. This is due to the fact that the grouping of reading strategies on the basis of the features of a particular hypertext fails when a hypertext does not possess these features.

We propose that reading strategies in hypertext can affect comprehension indirectly by leading the reader to process a particular text in terms of reading order and amount of information accessed. Different reading orders of the same text influence text comprehension in linear text (Danner, 1976; Kintsch & Yarbrough, 1982; Lodewijks, 1982; Mayer, 1976; Schnotz, 1982, 1984, 1993). Reading order has been manipulated following different criteria: self-regulated order vs. experimenter-regulated or logical order vs. random. Each manipulation of the reading order produced different comprehension outcomes, and also interacted with reader characteristics. For example, Schnotz (1982) reported an experiment in which two groups of participants read an expository text with the same contents but organized in different orders. The different paragraphs of the text were organized by object or by aspect. The author argued that an organization by aspect contains several thematic breaks in which the object is changed, so this type of organization could hamper text coherence. The opposite would hold for the object organization. Results showed an interaction between order and prior knowledge: Low knowledge readers recalled more information from the object organization while high knowledge recalled more information from the aspect organization. This result mimics the effect of knowledge and coherence, and could be explained in a similar way (McNamara et al., 1996; McNamara & Kintsch, 1996).

Reading strategies in hypertext can also determine the amount of information a reader accesses from a particular text. For example, readers following a strategy consisting of selecting the most interesting nodes could stop reading when they already read all the paragraphs considered interesting. In most of the experiments on hypertext comprehension the participants decides when they have finished reading.

As already stated, reading strategies can affect both the amount of information acquired and reading order. These two features of the text can have different effects on the text representation build by the reader. Specifically, we propose that the amount of information read by a given reader affects the textbase and that the order followed influences the situation model. The textbase representation consists of information derived from the original text. This representation would be richer as a reader reads a higher portion of the text, i.e., visited more different nodes. Some experimental evidence supports this prediction. Lawless and Kulikowich (1996) distinguished among groups of readers in a hypertext according to the number of different nodes accessed between other measures. These groups differed on the score of text-based questions.

The situation model is created from information in the text together with prior knowledge of the reader. During text processing the reader has to construct this representation by finding the appropriate place to connect each new piece of information with the knowledge structure acquired so far. The process of integrating the information on a coherent representation could be affected by the reading order of the information. For example, if a particular idea is stated in

Appendix I

node A and a conclusion derived from that is described in node D, the connection of both statements would require extra processing (e.g. in the form of bridging inferences) as the information (nodes) read between them increases (Kintsch & van Dijk, 1978). Some experimental results partially support this hypothesis (Foltz, 1996). Foltz analyzed the reading order of the participants in a hypertext comprehension experiment by measuring the coherence between the contents of the nodes transited. A transition between two nodes was considered coherent if both nodes were connected in the macrostructure of the text. The number of coherent transitions correlated with the number of important ideas included in an essay assessing the comprehension of the text.

Therefore, we hypothesize that the number of nodes accessed influences mainly the construction of the textbase, whereas the transitions between nodes is critical for the construction of the situation model. We tested these predictions in an experiment in which participants had to read a hypertext and perform some tasks testing both textbase and situation model comprehension. Data on participants' reading behavior was used a posteriori to analyze their comprehension scores.

Experiment 1

Experiment 1 assessed two hypotheses. First, does an increase in the amount of information read in a hypertext facilitate the construction of the textbase, as assessed by text-based questions. Second, do different orders in reading the sections in a hypertext lead to differences in the construction of the situation model, as assessed by inference questions and a cued association task. Participants read an expository text in hypertext format during a limited period of time. Participants' reading strategies (amount of different nodes accessed and reading order) was used a posteriori in order to predict their comprehension outcomes.

Method

Participants

Forty-one University of Colorado undergraduates participated for class credit.

Materials

Hypertext. An expository text on atmosphere pollution was adapted to a hypertext containing 24 nodes and 3,855 words. It consisted of three main sections with three levels of depth. The text readability was as follows: *Flesh Reading Ease* = 33.9; *Flesh-Kincaid Grade level* = 12. We constructed an overview presenting the hierarchy of contents that followed the paragraphing of the original text (see Figure 1). Participants were instructed to access the nodes by clicking on the titles provided on the overview. Once they read a node, they should return to the overview in order to decide what to read next. The hypertext and the rest of materials were implemented using HyperCard (R) and were run in Apple Macintosh (R) computers.

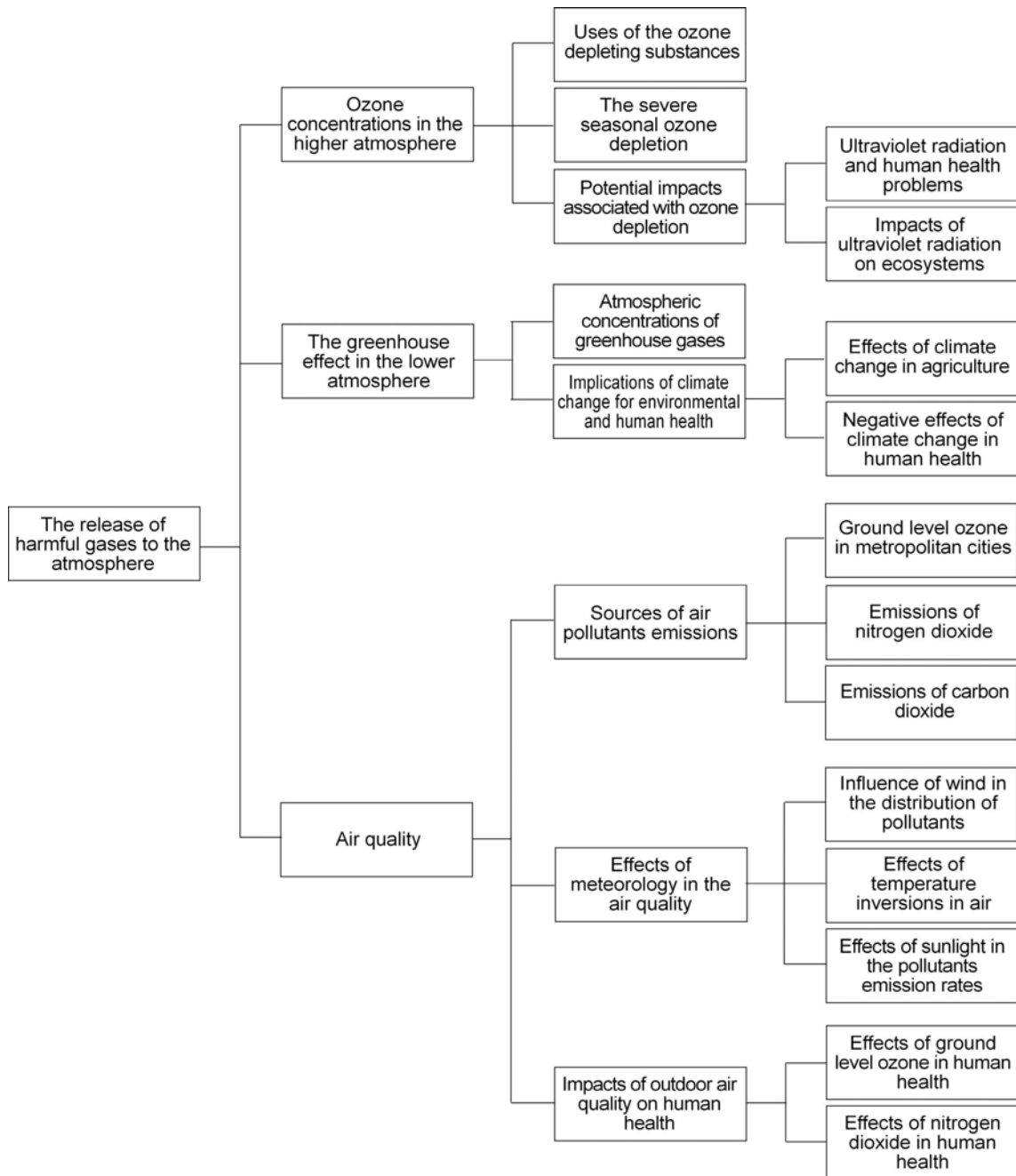


Figure 1. Overview used in experiment 1.

Appendix I

Coherence between nodes. Coherence between nodes was analyzed using Latent Semantic Analysis (LSA). The General Reading Space (available at the URL of the LSA group at the University of Colorado, <http://lsa.colorado.edu>) incorporated expository texts from high school textbooks up to the first year of college. The text of all the nodes was analyzed with the matrix analysis contrast (document to document comparison) that compares the contents of each node with every other. LSA cosines provided a measure of the degree of argument overlap between texts that is assumed to reflect the level of coherence between them (Foltz, Kintsch & Landauer, 1998). The rationale for this approach is that frequently when two propositions are in fact related semantically, there exists a shared argument between them (Kintsch, 1992). LSA cosines were used to explain possible differences between reading orders in comprehension outcomes.

Prior knowledge questions. Participants were given a pre- test of eight true/false questions to determine individual differences in domain knowledge previous to the reading phase. Half of the questions were true and the other half false. An example of this type of question was:

The Montreal Protocol is accepted by nations agreeing to restrict the release of ozone depleting chemicals. (True)

Text-based questions. We constructed a test consisting of 22 true/false questions for which the question and the answer appeared in a single node. Each question referred to the contents of a different node. Half of the questions were true and the other half false. An example of a text-based question was:

The two layers of the atmosphere closest to the earth's surface are critical in regulating earth climate. (True)

The answer to this question appeared in the following paragraph of a node:

The atmosphere consists of a relatively narrow shell of air encircling the earth that supports animal and plant life. Human activity specially affects the two layers of the atmosphere closest to the earth's surface: the troposphere which extends from the surface to about 12 miles, and the stratosphere, which extends from 12 miles up to approximately 30 miles. These portions of the atmosphere are critical in regulating our climate.

Cued association task. Participants were given a list of the 24 most important concepts in the text and were instructed to write down the three concepts that first came to mind after reading each concept on the list. Each response that contained a concept from the original list was computed. If the response was written first, it received a value of 1; if second, 0.66; and if third, 0.33. A PhD in Atmospheric Science of the National Center for Atmospheric Research provided expert ratings after reading the original text. We used these scores in order to compare the participants' solution with an expert one. The final score was obtained by calculating the proportion of each participant's links that were also present in the expert matrix. These scores were obtained by adding up the link strength values for only those connections in the participant matrix that were also included in the expert matrix, and dividing the result by the sum of all links of each participant matrix.

The cued association task has been developed in the framework of the C-I model of text comprehension, and has been validated to assess situation model comprehension (Ferstl & Kintsch, 1999). The C-I model assumes that during reading a text a reader forms a text representation network of the contents. The response pattern on the cued association task is assumed to correspond to the activation pattern on this network after probing with a concept cue.

Inference questions. We created 10 true/false inference questions that required the participant to relate information contained in at least two different nodes. Thus this task was also intended to assess situation model comprehension. Half of the questions were true and the other half false. An example of an inference question was:

Appendix I

While the ozone in the higher and lower levels of the atmosphere is chemically identical, its environmental effects differ greatly. (True)

To answer this question participants had to relate information contained in three different nodes:

(1) Ozone is a naturally occurring gas molecule containing three atoms of oxygen. It is mainly found in two parts of the atmosphere: most (about 90%) resides in the upper atmosphere or stratosphere, where it forms the stratospheric ozone layer ; the remaining ozone, referred to as ground level ozone or tropospheric ozone, is present in the lower region of the atmosphere.

(2) A range of negative environmental and human health impacts associated with ozone depletion can be identified, although their exact nature is difficult to quantify. Known effects include increased incidence of skin cancers and eye disorders (e.g. cataracts), damage to the immune system and adverse effects on plant development and phytoplankton growth.

(3) Observed effects of ground level ozone on human health include irritation of the eyes and air passages, damage to the mechanisms that protect the human respiratory tract and for some asthma sufferers, increased sensitivity of the airways to allergic triggers.

Procedure

First participants went through a pre-test of eight true/false questions assessing their domain knowledge. They were then instructed on how to use the hypertext. After that, they were required to read the contents during 20 minutes. The instructions stressed that they had to read the text carefully in order to answer a series of questions after the time was concluded. At this point, participants had to perform a cued association task. Finally, participants had to answer 22 true/false text-based questions and 10 true/false inference questions mixed randomly.

Design

We used reading order (see below) and different nodes accessed as independent variables, and the scores on text-based questions, cued association and inference questions as dependent variables.

Results

For all experiments, differences declared as significant have $p < .05$.

Analysis of amount of information read

The first hypothesis stated that an increase in node access would facilitate the construction of the textbase. We performed a regression analysis with the number of different nodes accessed as independent variable, and the score on the text-based questions as dependent variable. Results showed that node access significantly predicted the score on the text-based questions, $R^2 = 0.11$, $F(1, 39) = 4.85$. As node access increased, so did text-based scores. Follow up analysis were made in order to explore a possible influence of prior knowledge on this effect. Participants were divided in two groups based on a mean split of their prior knowledge scores. 18 participants were included in the low knowledge group, $M = 3.17$, $SD = 1.03$, and 23 in the high knowledge, $M = 6.33$, $SD = 1.24$. Regression analysis for each group revealed that the effect of node access was significant for low knowledge readers, $R^2 = 0.25$, $F(1, 21) = 6.98$, but not for high knowledge, $R^2 = 0.01$, $F < 1$.

In addition, we also expected that node access would not predict comprehension at the situation model level. Supporting the null hypothesis, none of the analyses showed significant results either for the cued association scores, $R^2 = 0.03$, $F(1, 39) = 2.34$, $p < .15$., or for the inference questions, $R^2 = 0.06$, $F(1, 39) = 2.83$, $p < .15$. Furthermore, no significant differences were found when the analysis were performed for each group of prior knowledge.

Analysis of reading order

A look at the node-transition matrices revealed at least two main reading orders. Participants in order 1 followed the map of contents in a linear fashion and in order 2 they followed a top down path, starting visiting the highest nodes

Appendix I

of the hierarchy and continuing to the lowest levels. We constructed two theoretical matrices representing both orders, and correlated them with the node-transition matrices of all participants. Participants' matrices with a correlation higher to the 75% percentile were grouped into the corresponding order. Participants' matrices with a lower correlation were grouped under a third order, which included participants that followed a combination of order 1 and 2, and those that read the contents in a different order. Participants were distributed as follow: order 1, (13 participants), order 2, (11), and order 3, (17).

Hypothesis 2 predicted that participants following different reading orders would differ in comprehension at the situation model level. We performed an ANOVA with reading order as independent variable, and cued association scores as dependent variable. Results showed a main effect of reading order, $F(2, 38) = 7.81$, $MSE = 0.02$. Participants following the order 1 had better cued association scores ($M = 0.48$, $SD = 0.16$) than those of the order 2 ($M = 0.35$, $SD = 0.1$) and order 3 ($M = 0.29$, $SD = 0.11$). Similar results were found with inference questions as dependent variable, $F(2, 38) = 4.15$, $MSE = 266.24$. Participants following the order 1 successfully answered more inference questions ($M = 83.5\%$ correct, $SD = 11.4$) than those of the order 2 ($M = 71.4\%$, $SD = 19.2$) and order 3 ($M = 66.4\%$, $SD = 17.4$). In order to account for possible influences of prior knowledge in the effects found, we performed two ANOVAs including prior knowledge as covariate. In both cases (cued association and inference questions scores) the differences between group 1 and groups 2 and 3 remained significant.

In addition, we expected that reading order would not differ on the text-based questions scores. Supporting the null hypothesis, no differences were found between the order on the text-based questions scores, $F(2, 38) = 1.38$, $MSE = 268.4$, $p < .3$.

In order to explain the differences found between reading orders we compared the different groups on different dependent variables: level of prior knowledge, nodes accessed and the coherence of the transitions (measured as the mean LSA cosine of all the transitions). Participants of the three order groups did not differ in prior knowledge, $F < 1$. However, they differed on the nodes accessed, $F(2, 38) = 4.76$, $MSE = 5.54$. Participants in the group 1 accessed more different nodes ($M = 24.07$, $SD = 1.18$) than those in the group 3 ($M = 21.41$, $SD = 2.62$), and both of them were not different from the group 2 ($M = 22.81$, $SD = 2.89$). In addition, reading order groups differed on the coherence of their transitions, $F(2, 38) = 19.77$, $MSE = 0.01$. Participants of the order 1 followed a more coherent path (mean cosine, $M = 0.5$, $SD = 0.01$) than those of the order 2 ($M = 0.44$, $SD = 0.02$) and order 3 ($M = 0.45$, $SD = 0.03$).

Discussion

The results of experiment 1 support the hypothesis that the amount of information accessed and the reading order influence the reader's comprehension level in two different ways. First, the different number of nodes accessed predicts scores on text-based questions for low knowledge readers. Participants that read more different texts form a better textbase of the contents. Although this result can be seen as an obvious statement, it is relevant for the literature on hypertext comprehension, since in most experiments on hypertext comprehension it is the participant who decides when he / she has finished reading the contents. The results also show that this effect is influenced by prior knowledge: low knowledge readers learn more by reading more nodes, whereas high knowledge are not affected by it. A possible explanation for this effect is that high knowledge readers could use their prior knowledge to try to fill in gaps in the information presented in the nodes not read. For that reason, the loss of relevant information for the textbase due to an incomplete reading of the materials is lower for high knowledge than for low knowledge readers.

Participants that read the text in different order get different learning outcomes at the situation model level. Differences due to the reading order seem to rely on two different variables: nodes accessed and coherence between node transitions. On the one hand, the better learning of the reading order group 1 compared to the group 3 seem to be influenced by the nodes accessed (higher number for group 1 than for group 3). This result suggests that in order to

Appendix I

construct an appropriate situation model a minimum number of nodes must be read. On the other hand, providing that a similar number of nodes are read (i.e. group 1 versus group 2), differences on the learning outcome seem to be related to the coherence between node transitions (Foltz, 1996). Participants that read the contents in a high coherent order form a better situation model of the text. This effect can be explained by the fact that transitions between two paragraphs that do not share arguments (coherence) will require extra processing (e.g. in the form of bridging inferences) in order to maintain the coherence of the text representation (Kintsch & van Dijk, 1978). Although these results of reading order seem to be independent of the prior knowledge of the reader, the method used (analysis of covariance) and the limited number of participants per reading order group prevent us from making any strong conclusion. For that reason, in experiment 2 the role of prior knowledge and reading order will be addressed in more detail.

Since most of the previous studies have not controlled for these effects, they can be considered as a possible factor affecting the confusing state of the literature on hypertext comprehension. If these effects are not controlled, comprehension outcomes for a condition could depend on the particular distribution of participants following the different strategies. Since reading strategies can influence comprehension by leading the reader to read a particular text, it can be expected that a failure to control its influence might particularly mask those expected effects related to text characteristics. For example, Foltz (1996) designed an experiment with two conditions, one intended to provide high text coherence by including extra information for understanding the contents of a node when a non-coherent transition was made, and another without such a help. Contrary to expectations, there were no comprehension differences between conditions. This result could be explained by the fact that both groups of participants followed similar high coherent reading orders (Foltz, 1996, p. 128).

A similar problem could arise while attempting to replicate the effect of knowledge and coherence, not thus far replicated in hypertext comprehension: low knowledge readers form a better situation model from a coherent text than from an incoherent one, whereas high knowledge readers learn more from an incoherent one (McNamara et al., 1996; McNamara & Kintsch, 1996). In order to replicate this effect, a traditional experiment would present two different overviews trying to promote low and high coherence. But since in each condition participants could follow different reading orders, the path followed could affect comprehension independently of the overview used (e.g. Foltz, 1996). Therefore, we propose that the effect of knowledge and coherence could be replicated in hypertext if participants follow a low and a high coherence reading order.

This approach was tested in experiment 2, in which we tried to replicate the effect of knowledge and coherence not yet replicated in hypertext. In a pilot study we provided an overview in which the titles of the contents were distributed in a 6 x 4 array. We found that 17 out of 37 participants followed a strategy consisting of reading the contents from the first row from left to right and continuing the next row down. We decided to construct two overviews with an organization that provided low versus high coherence respectively (in terms of reading order) if a reader followed the left-right strategy. By doing that we expected to show that learning differences could be found between reading orders, but not necessarily between overviews. Therefore, we expected that the effect of knowledge and coherence would appear when comparing participants following a low versus a high coherence transition order, but not when comparing the overviews.

Experiment 2

Experiment 2 assessed two hypotheses. First, would participants with high domain knowledge construct a better situation model (assessed by inference questions and a cued association task) when following a strategy that lead to a low coherence order than when following a strategy that lead to a high coherence order. Second, would participants with low domain knowledge construct a better situation model when following a strategy that lead to a high coherence

Appendix I

order than when following a strategy that lead to a low coherence order. Participants read the same text as in experiment 1 but with a different overview. For one group, the overview promoted a high coherent reading order, whereas for the other the overview promoted a low coherent reading order. Coherence of participants' reading order was used a posteriori in order to assess possible differences on their comprehension outcomes.

Method

Participants

Eighty-two University of Colorado undergraduates participated for class credit.

Materials

Hypertext. We used the same hypertext presented in experiment 1 except for the overview provided. Two different overviews were created, in which nodes were arranged in a 6 x 4 array. Coherence between contents was assessed using LSA as in experiment 1. In one overview nodes were arranged in a manner that provided the lowest coherence between transitions, when reading from left to right and from top to down. This was done by arranging the nodes in an order in which the sum of LSA cosines between nodes was the lowest possible. In a second overview nodes were arranged for providing the highest coherence between transitions, when reading from left to right and from top to down. This was done by arranging the nodes in the order in which the sum of LSA cosines between nodes was the highest possible. Comprehension tasks were the same as used in experiment 1.

Procedure

Procedure was identical to that of experiment 1, except for the reading phase. Since the effect of knowledge and coherence is mainly related to situation model comprehension, we tried to control the effect of the variable nodes accessed on the textbase found in experiment 1 using a different procedure. Specifically, in experiment 2 participants had to read all the contents without time limit. Participants were not able to reread nodes.

Design

We used a 2 x 2 between groups design with prior knowledge (low and high), and overview (low and high coherence) as independent variables. The two levels of prior knowledge were defined according to the mean split of the answers to the eight true/false questions about the participants' domain knowledge. The mean score was 5.62, $SD = 1.23$. Participants with scores below the mean were classified as low knowledge ($n = 39$, $M = 4.51$, $SD = 0.64$) and those above as high knowledge ($n = 43$, $M = 6.63$, $SD = 0.79$).

We also used reading order (low and high coherence) as a quasi-experimental variable. For that purpose we analyzed the coherence of the reading sequence as in experiment 1 (mean LSA cosine of all the transitions). We used the extreme tiers for the coherence values, the lower boundary being the 40th percentile (cosine = 0.38), $M = 0.32$, $SD = 0.03$, and the higher being the 60th percentile (cosine = 0.41), $M = 0.47$, $SD = 0.03$. Therefore, the distribution of participants by prior knowledge and reading order was as follows: low knowledge low coherence 21 participants; low knowledge high coherence 16; high knowledge low coherence 11; and high knowledge high coherence 19. The dependent variables were scores on the text-based and inference questions and on the cued association task.

Results

In order to show the consequences of not considering the reading order we performed two ANOVAs. First, we conducted an ANOVA with prior knowledge (low and high), and overview (low and high coherence) as independent variables, and cued association scores as dependent variable. There were no significant differences ($F(1, 78) = 2$, $MSE = 0.02$, $p < .2$ for the interaction). The same null results were found for the dependent variable inference questions scores ($F(1, 78) = 2.18$, $MSE = 393.7$, $p < .15$ for the interaction). Therefore, in agreement with previous research, the effect of knowledge and coherence did not appear when considering all participants without taking into account the reading order. Second, we performed another two ANOVAs with reading order (low and high coherence) instead of overview.

Appendix I

In this case, the interaction for cued association scores was significant, $F(1, 63) = 8.38$, $MSE = 0.02$. Participants with low knowledge performed better on the cued association task when following a strategy leading to high coherence ($M = 0.4$, $SD = 0.17$) than when following a low coherence one ($M = 0.28$, $SD = 0.09$); whereas the opposite was found for participants with high knowledge ($M = 0.29$, $SD = 0.11$ and $M = 0.39$, $SD = 0.17$ respectively). Simple effects were analyzed for prior knowledge (low and high). Results showed a significant difference for low knowledge participants, $t(63) = 7.45$, $MSE = 0.02$ and a close to significant difference for high knowledge, $t(63) = 3.35$, $MSE = 0.02$, $p = 0.07$. Similar results were obtained with inference questions scores as dependent variable. Only the interaction was significant, $F(1, 63) = 7.21$, $MSE = 2.49$. Participants with low knowledge scored higher when following a strategy leading to high coherence ($M = 67.2\%$ correct, $SD = 15.7$) than when following the a coherence one ($M = 55.4\%$, $SD = 17.5$); whereas the opposite was found for participants with high knowledge ($M = 53.3\%$, $SD = 24.2$ and $M = 68.2\%$, $SD = 20.4$ respectively). Simple effects analysis for prior knowledge revealed that these differences were close to significant for low knowledge readers, $t(63) = 3.26$, $MSE = 2.49$, $p = 0.07$, and significant for high knowledge, $t(63) = 3.96$, $MSE = 2.49$.

Since in experiment 2 participants could decide the time spent reading the text, the influence of reading time was assessed. First, an ANOVA showed no effect for prior knowledge nor for reading order, ($F < 1$ for the interaction). Second, correlation analysis showed no significant relations between reading time and any of the comprehension variables.

Finally, although it was not considered in our hypotheses, we also run an ANOVA with prior knowledge (low and high), and reading order (low and high coherence) as independent variables, and text-based scores as dependent variable. The objective was to replicate the effect found in experiment 1 showing that the reading order does not affect the construction of the textbase. Supporting this idea, neither the main effect of reading order nor the interaction were significant ($F < 1$ in both cases). There was only a close to significant effect of prior knowledge, $F(1, 63) = 3.29$, $MSE = 5.43$, $p = 0.07$. Participants with low knowledge scored lower than high knowledge ($M = 61.5\%$ correct, $SD = 10.4$ and $M = 66.8\%$, $SD = 12.7$ respectively).

Discussion

The results of experiment 2 show that the effect of knowledge and coherence are replicated in hypertext for those participants following a particular strategy that lead them to read the contents in a low or high coherent order. Participants with low knowledge benefit more at the situation model level when reading the contents in a high coherence order, whereas participants with high knowledge learn more from a low coherence order (McNamara et al., 1996; McNamara & Kintsch, 1996; Schnotz, 1982). Results show that this effect is not related to the reading time of the materials. Moreover, when considering only the experimental conditions manipulated by the experimenter (type of overview) this effect disappears, masked by the joint effect of the different reading strategies followed by participants. Therefore, it can not be expected that an effect on hypertext comprehension would hold for all participants of a condition, but only for those participants following a particular strategy that allows the experimental manipulations to become effective (in this case high and low coherence due to the reading order).

In addition, data of the text-based questions show that the reading order does not affect the textbase construction. Participants following a low versus high coherent order do not differ on the text-based scores, although they do on two situation model measures. This result supports the effect found in experiment 1, showing that text-based scores are positively related to the number of different nodes read, but not to the reading order.

General discussion

The two experiments reported here reveal that reading order and amount of information read have distinctive effects on the representation of the text that readers form when reading a hypertext. While the amount of information read influences mainly the construction of the textbase, the reading order influences the construction of the situation model. In addition, these results stress the importance of text coherence as a feature derived from the reading order (Foltz, 1996), and its different effect on comprehension depending on the domain knowledge of the reader (McNamara et al., 1996; McNamara & Kintsch, 1996). Differences were found between low knowledge readers following a strategy that lead them to read the text in a coherent order, and high knowledge readers following a strategy that lead them to read the text in an incoherent order.

Considering that previous research has paid little attention to these effects, it could be affirmed that a failure to control for these effects could be one of the possible reasons for the inconsistent results found in the literature. As shown in experiment 2, comprehension effects due to text characteristics only appear after the reading order is considered. Therefore, an important issue that needs to be addressed is how to control these effects in hypertext comprehension experiments. The effect of amount of information accessed could be easily controlled by forcing the participants to read all the paragraphs of the experimental text, as done in experiment 2. But the effect of the reading order is hard to control since freedom of choosing a reading order is the very essence of reading a hypertext. A possible solution could consist of using appropriate criteria for the comparison of different reading orders. In the present work, the coherence between nodes assessed by LSA was revealed as an important variable affecting comprehension (Foltz, Kintsch & Landauer, 1998). Therefore, researchers could consider this variable as a possible comparison criterion between reading orders.

In the present work we assessed the effects on comprehension of reading strategies due to their influence on the final text read by the reader in terms of amount of information read and reading order. In that sense, these effects can be considered bottom-up. However, reading strategies could also influence comprehension in a top-down fashion (e.g. Magliano et al., 1999). Therefore, researchers need to consider both the different types of strategies that readers follow while reading a hypertext, and their different effects on comprehension. Previous works in the literature on text comprehension in linear text could be a possible starting point for that purpose. When reading a linear text a reader can move through the different sections of the text, e.g. for revisiting information previously read. Goldman and Saul (1990) have proposed the Strategy Competition Model, that states that readers' progress through a text trying to establish global discourse coherence. If at one point the reader detects a gap in his / her comprehension of the contents, he / she would move through the text looking for the necessary information in order to fill this gap. Therefore, it is important to consider in further research if readers of a hypertext use text coherence as a rule for selecting what node to read next. While the results of the first experiment presented here stress the importance of text coherence in hypertext comprehension, they cannot be considered as an strong evidence for this hypothesis. Instead, participants seemed to rely on the overview to read the contents, so in this case coherence could be considered as an indirect consequence of their reading strategy. Further research will be required to fully understand the effects of reading strategies on hypertext comprehension.

References

- Barab, S. A., Bowdish, B. E., & Lawless, K. A. (1997). Hypermedia navigation: profiles of hypermedia users. *Educational Technology Research and Development, 45*, 23-42.
- Barab, S. A., Bowdish, B. E., Young, M. F., & Owen, S. V. (1996). Understanding kiosk navigation: using log files to capture hypermedia searches. *Instructional Science, 24*, 377-395.
- Barab, S. A., Fajen, B. R., Kulikowich, J. M. & Young, M. F. (1996). Assessing hypertext navigation through Pathfinder: prospects and limitations. *Journal of Educational Computing Research, 15*, 185-205.
- Barab, S. A., Young, M. F., & Wang, J. (1999). The effects of navigational and generative activities in hypertext learning on problem solving and comprehension. *International Journal of Instructional Media, 26*, 283-309.
- Brinkerhoff, J. D., Klein, J. D., & Koroghlanian, C. M. (2001). Effects of overviews and computer experience on learning from hypertext. *Journal of Educational Computing Research, 25*, 427-440.
- Britt, M.A., Rouet, J.-F., & Perfetti, C.A. (1996). Using hypertext to study and reason about historical evidence. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 43-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, R., & Glaser, R. (1989). Self-explanation: How students study and use examples in learning to solve problems. *Cognitive Science, 13*, 145-182.
- Chi, M. T. H., De Leeuw, M., Chiu, M., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science, 18*, 439-477.
- Danner, F. W. (1976). Children's understanding of intersentence organization in the recall of short descriptive passages. *Journal of Educational Psychology, 68*, 174-183
- De Jong, T., & Van der Hulst, A. (2002). The effects of graphical overviews on knowledge acquisition in hypertext. *Journal of Computer Assisted Learning, 18*, 219-231.
- Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research, 68*, 322-349.
- Ferstl, E. C., & Kintsch, W. (1999). Learning from text: Structural knowledge assessment in the study of discourse comprehension. In H. Van Oostendorp & S. R. Goldman (Eds.), *The construction of mental representations during reading* (pp. 247-277). Mahwah, NJ: Lawrence Erlbaum Associates.
- Foltz, P. W. (1996). Comprehension, coherence, and strategies in hypertext and linear text. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 109-136). Mahwah, NJ: Lawrence Erlbaum Associates.
- Foltz, P. W., Kintsch, W., & Landauer, T. K. (1998). The measurement of textual coherence with Latent Semantic Analysis. *Discourse Processes, 25*, 285-307.
- Goldman, S. R., Saul, E., & Coté, N. (1995). Paraphrasing, reader, and task effects on discourse comprehension. *Discourse Processes, 20*, 273-305.
- Goldman, S. R., & Saul, E. (1990). Flexibility in text processing: a strategy competition model. *Learning and Individual Differences, 2*, 181-219.
- Hofman, R., & Van Oostendorp, H. (1999). Cognitive effects of a structural overview in a hypertext. *British Journal of Educational Technology, 30*, 129-140.
- Horney, M. A., & Anderson-Inman, L. (1994). The electrotext project: hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia, 3*, 71-91.
- Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review, 95*, 163-182.

Appendix I

- Kintsch, W. (1992). How readers construct situation models for stories: The role of syntactic cues and causal inferences. In A. F. Healy, S. N. Kosslyn & R. M. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes* (pp. 216-278). Hillsdale, N.J.: Lawrence Erlbaum Associates.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.
- Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review*, 85, 363-394.
- Kintsch, W., & Yarbrough, J. C. (1982). The role of rhetorical structure in text comprehension. *Journal of Educational Psychology*, 74, 828-834.
- Lawless, K. A., & Kulikowich, J. M. (1996). Understanding hypertext navigation through cluster analysis. *Journal of Educational Computing Research*, 14, 385-399.
- Lawless, K. A., & Kulikowich, J. M. (1998). Domain knowledge, interest, and hypertext navigation: a study of individual differences. *Journal of Educational Multimedia and Hypermedia*, 7, 51-70.
- Lawless, K. A., Mills, R., & Brown, S. W. (2002). Children's hypermedia navigational strategies. *Journal of Research on Computing in Education*, 34, 274-284.
- Lodewijks, H. (1982). Self-regulated versus teacher-provided sequencing of information in learning from text. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 509-520). Amsterdam: North-Holland.
- Lorch, R. F., Jr. (1989). Text-signaling devices and their effects on reading and memory processes. *Educational Psychology Review*, 1, 209-234.
- Magliano, J. P., Trabasso, T. & Graesser, A. C. (1999). Strategic processing during comprehension. *Journal of Educational Psychology*, 91, 615-629.
- Mayer, R. E. (1976). Some conditions of meaningful learning for computer programming: advance organizers and subject control of frame order. *Journal of Educational Psychology*, 68, 143-150.
- McNamara, D. S., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interaction of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1-42.
- McNamara, D. S., & Kintsch, W. (1996). Learning from text: effect of prior knowledge and text coherence. *Discourse Processes*, 22, 247-288.
- McNamara, D. S., & Scott, J. L. (1999). Training reading strategies. *Proceedings of the Twenty-first Annual Meeting of the Cognitive Science Society* (pp. 387-392). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Moeller, J., & Mueller-Kalthoff, T. (2000). Lernen mit hypertext: effekte von navigationshilfen und vorwissen [Learning with hypertext: the impact of navigational aids and prior knowledge]. *Zeitschrift für Pädagogische Psychologie*, 14, 116-123.
- Moravesik, J. E., & Kintsch, W. (1993). Writing quality, reading skills, and domain knowledge as factors in text comprehension. *Canadian Journal of Experimental Psychology*, 47, 360-374.
- Mueller-Kalthoff, T., & Moeller, J. (2003). The effects of graphical overviews, prior knowledge, and self-concept on hypertext disorientation and learning achievement. *Journal of Educational Multimedia and Hypermedia*, 12, 117-134.
- Naumann, A., Waniek, J. & Krems, J. F. (2001). Knowledge acquisition, navigation and eye movements from text and hypertext. In U. D. Reips & M. Bosnjak (Eds.), *Dimensions of Internet Science* (pp. 293-304). Lengerich, Germany: Pabst.
- Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, 23, 237-255.

Appendix I

Potelle, H., & Rouet, J.-F. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies*, 58, 327-345.

Pressley, M., Symons, S., McDaniel, M. A., Snyder, B. L., & Turnure, J. E. (1988). Elaborative interrogation facilitates acquisition of confusing facts. *Journal of Educational Psychology*, 80, 268-278.

Puntambekar, S., Stylianou, A., & Hübscher, R. (2003). Improving navigation and learning in hypertext environments with navigable concept maps. *Human-Computer Interaction*, 18, 395-428.

Quathamer, D., & Heineken, E. (2002). Kohärenzbildung beim lesen von texten: fishye-views als kognitive werkzeuge [Maintaining global coherence during reading: fisheye views as cognitive tools]. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, 34, 72-79.

Rouet, J.-L., Favart, M., Britt, M. A. & Perfetti, C. A. (1997). Studying and using multiple documents in history: Effects of discipline expertise. *Cognition & Instruction*, 15, 85-106.

Schnotz, W. (1982). How do different readers learn with different text organizations? In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 87-97). Amsterdam: North-Holland.

Schnotz, W. (1984). Comparative instructional text organization. H. Mandl, N. L. Stein, & T. Trabasso (Eds.), *Learning and comprehension of text* (pp. 53-81). Hillsdale, N. J.: Lawrence Erlbaum Associates.

Schnotz, W. (1993). Adaptive construction of mental representations in understanding expository texts. *Contemporary Educational Psychology*, 18, 114-120.

Shapiro, A. M. (1998). Promoting active learning: The role of system structure in learning from hypertext. *Human-Computer Interaction*, 13, 1-35.

Shapiro, A. M. (1999). The relationship between prior knowledge and interactive overviews during hypermedia-aided learning. *Journal of Educational Computing Research*, 20, 143-167.

Shapiro, A. M. (2000). The effect of interactive overviews on the development of conceptual structure in novices learning from hypermedia. *Journal of Educational Multimedia and Hypermedia*, 9, 57-78.

Snapp, J. C., & Glover, J. A. (1990). Advance organizers and study questions. *Journal of Educational Research*, 83, 266-271.

Trabasso, T., & Magliano, J. P. (1996). Conscious understanding during text comprehension. *Discourse Processes*, 21, 255-288.

Unz, D. C., & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, 20, 279-295.

Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.

Wagner, R. K. & Sternberg, R. J. (1987). Executive control in reading comprehension. In B. K. Britton & S. M. Glynn (Eds.), *Executive control processes in reading* (pp. 1-22). Hillsdale, NJ: Lawrence Erlbaum Associates.

Waniek, J., Brunstein, A., Naumann, A., & Krems, J. F. (2003). Interaction between text structure representation and situation model in hypertext reading. *Swiss Journal of Psychology*, 62, 103-111.

APPENDIX II

Salmerón, L., Kintsch, W. & Cañas, J.J. (in press). Reading Strategies and Prior Knowledge in Learning from Hypertext. *Memory & Cognition*.

Abstract

In two experiments we identified two main strategies followed by hypertext readers in order to select their reading order, the first consisted in selecting the text semantically related to the previously read section (coherence strategy) and the second in choosing the most interesting text delaying less interesting sections (interest strategy). Comprehension data revealed that these strategies distinctly affected learning depending on the reader's prior knowledge. For low knowledge readers, the coherence strategy supported better learning of the content. The nature of this effect seems to rely on the improvement of reading order coherence induced by this strategy. By contrast, for intermediate knowledge both the coherence and interest strategy benefited comprehension equally. In both cases, learning was supported through the active processing induced by these strategies. Discussion focuses on resolving inconsistencies in the literature concerning whether hypertext supports better comprehension than traditional linear texts.

Introduction

Comprehending a text in hypertext format requires the same cognitive processes involved in reading a traditional linear text. However, hypertext demands an additional cognitive process that is minimized when reading a linear text: the selection of the reading order of the text sections (but see Dillon, 1991; Goldman & Saul, 1990; Goldman, Saul & Coté, 1995, for the study of order selection in linear text). Hypertext readers follow different strategies to select the reading order, which can affect comprehension (Anderson-Inman & Horney, 1994; Barab, Bowdish, & Lawless, 1997; Barab, Bowdish, Young, & Owen, 1996; Barab, Fajen, Kulikowich & Young, 1996; Barab, Young & Wang, 1999; Britt, Rouet & Perfetti, 1996; Foltz, 1996; Horney & Anderson-Inman, 1994; Lawless & Kulikowich, 1996, 1998; Lawless, Mills & Brown, 2002; Niederhauser, Reynolds, Salmen & Skolmoski, 2000; Rouet, Favart, Britt & Perfetti, 1997; Salmerón, Cañas, Kintsch & Fajardo, in press). However, until now there is no agreement in the literature regarding the strategies that hypertext readers follow when their main purpose is to comprehend a text (Unz & Hesse, 1999). The identification and analysis of these strategies would allow the determination of how order selection affects comprehension and if the use of this feature could result in improved learning when compared to linear texts.

Two main approaches have been used to describe hypertext reading strategies: the analysis of the navigational path and the description of the criteria followed in the selection of reading order. The first approach consists in the identification of similar groups of navigational paths using a multidimensional scaling technique. Research in this approach starts without any hypothesis about which strategies people might use, and it is the multidimensional scaling technique which allows for identifying the groups that the researcher will later interpret. One of the most extended classifications is the one put forth by Lawless & Kulikowich (1996, 1998; see also Anderson-Inman & Horney, 1994; Barab et al., 1997), which identified three main navigational groups: knowledge seekers, feature explorers and apathetic hypertext users. Knowledge seekers spend most of the reading time on content related documents, whereas feature explorers do that on the special features of the hypertext (as images, videos, maps). Finally, apathetic users spend short intervals of time on content related documents, and seem to follow a random reading order. However, later experiments describe other navigational groups, suggesting that the navigational path found in an experiment often depends on the particular hypertext used (in terms of content structure and additional features), the particular technique and the particular way of using it (e.g. number of groups in a cluster analysis). This makes it difficult to compare results between experiments.

The second approach for assessing reading strategies describes theoretically the general criteria followed by participants when selecting the reading order. This has been done by analyzing cognitively relevant aspects of the reading order (e.g. text coherence between paragraphs transited) or by using the think aloud methodology (Foltz, 1996).

Appendix II

This approach overcomes the limits of the grouping of the navigational path, because it allows for a fair comparison between experiments and makes it possible to relate the strategies to cognitive models of comprehension. Following this approach, Foltz (1996) identified the coherence strategy, which consists in the selection of the reading order that builds a thematically coherent reading sequence. The description of this strategy is inspired by the Strategy Competition Model of Goldman and Saul (1990), which states that readers progress through a text trying to establish global discourse coherence. If at one point the reader detects a gap in his / her comprehension of the content, he / she would move through the text looking for the necessary information in order to fill this gap. However, as some previous research reveals, the coherence strategy is not the only one followed by hypertext readers. For example, Ainley, Hidi and Berndorff (2002) presented high-school students four texts on different topics that could be read in a self-selected order. They concluded that some participants first selected the sections they considered most interesting, thus delaying the selection of the less interesting ones.

In the present work we follow the second approach in order to identify the main reading strategies followed by hypertext readers and to explain their effects on comprehension in relation to general theories of text comprehension. We consider that we needed our first step to empirically identify the coherence and interest strategies, because the prior literature is not sufficiently conclusive. Regarding the coherence strategy, it has been found that the coherence (i.e. semantic relation) between the transited sections is positively correlated to learning outcomes (Foltz, 1996). However, this effect does not necessarily constitute evidence that hypertext readers look actively for coherence, because one could just follow passively the structure of the hypertext content in order to construct a high-coherent reading order (Salmerón et al., in press). Regarding the interest strategy, it has been proposed that the interest induced by the section title is positively related to the order in which a title will be selected (Ainley et al., 2002). However, the authors reported that approximately 50% of the participants just read the text following the order in which they were presented on the screen, so they were not able to correlate the interest for the title with the selection order (p. 550). Therefore, in order to empirically validate these strategies, we conducted two pilot studies in which we asked participants to describe in their own words the main criteria they followed for moving through the hypertext while trying to comprehend a text. An expository text divided into 24 pages was used in both experiments. In the first experiment, an overview of the content was provided from which the readers could access any of the documents; in the second, no overview was used. A total of 61 participants participated in both studies (30 in experiment 1, 31 in experiment 2). Although most of the participants declared that they did not follow any strategy (62%), from the affirmative responses we identified three criteria: coherence (selecting the link most directly related to the one previously read) (25%), interest (selecting the considered most interesting links) (11%), and easiness (selecting the considered easiest links) (2%). However, those percentages should be interpreted cautiously. The selection of a particular strategy for comprehending a text could depend on several features of both the hypertext and the reader. In addition, the method employed in these pilot studies of simply asking a general question could have magnified the number of negative responses (i.e. no strategy followed) obtained. Nevertheless, a fair interpretation of these results allows for identifying the two reading strategies followed by hypertext readers suggested by previous research: coherence (as in Foltz, 1996) and interest (as in Ainley et al., 2002). Therefore, in the remainder of the text we will analyze these two strategies and their relation to text comprehension.

Reading strategies and text comprehension

To explore the effects of reading strategy on comprehension in hypertext we will start with the Construction-Integration (C-I) model of text comprehension (van Dijk & Kintsch, 1983; Kintsch, 1988; 1998). The C-I model conceives of comprehension as a process of relating the ideas of a text into a coherent representation. This is accomplished in two phases: the construction process generates a network of interconnected propositions from the text

Appendix II

and the integration phase identifies the highly interconnected links by a spreading activation process. Information from the text is processed in serial cycles. Therefore, in order to maintain coherence between segments, the one or two nodes most highly weighted at the end of a cycle are stored in working memory to be available in the next processing cycle. The model distinguishes between two of the mental representations that a reader forms from the text: the textbase, a hierarchical propositional representation of the information within the text; and the situation model, which integrates that information with reader's prior knowledge. According to the C-I model, many factors contribute to text comprehension, but coherence and prior knowledge are the main factors. Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text and is usually related to an increase in comprehension (Britton & Gülgöz, 1991).

Different reading strategies induce readers to focus on different aspects of the text, which could be critical in determining the kind of interconnections established between the information read. This relation between reading strategies and comprehension has been extensively reported in the literature (Chi, Bassok, Lewis, Reimann & Glaser, 1989; Chi, De Leeuw, Chiu & LaVancher, 1994; Magliano, Trabasso & Graesser, 1999; McNamara, 2004; McNamara & Scott, 1999; Pressley, Symons, McDaniel, Snyder & Turnure, 1988; Trabasso & Magliano, 1996; Wagner & Sternberg, 1987). There is no reason to argue that this relation found in the literature of linear text comprehension does not hold for hypertext comprehension. However, when studying the influence of reading strategies on hypertext an additional feature needs to be considered: reading strategies determine the order in which the text is going to be read, and this could affect its comprehension (Danner, 1976; Kintsch & Yarbrough, 1982; Lodewijks, 1982; Mayer, 1976; Schnotz, 1982, 1984, 1993). The reading order itself plays an important role in comprehension, because it can influence the process of relating text ideas. For example, a text written following a coherent scheme (e.g. temporal sequence of the events) can become less coherent if read in a random order. In sum, we propose that reading strategies in hypertext could affect comprehension in two different ways: from a strategic influence associated with the reading strategy followed by the reader and from a text-induced influence related to the changes in text order coherence (Salmerón et al., in press). Although there is extensive work supporting these two influences in isolation, in hypertext both act conjointly in determining the learning outcome of the reader. Following this distinction, we will explore how the coherence and interest strategies affect comprehension in hypertext following the C-I model. In addition, because the model stresses the role of prior knowledge in comprehension, we will consider this variable in our exposition.

Hypertext reading strategies and prior knowledge

First we will focus on the coherence strategy. This strategy involves selecting nodes semantically related to the previously read nodes in order to establish a coherent reading order of the different documents (Foltz, 1996). We will explore both the text-induced and strategic influences, and the interaction with prior knowledge. Considering the text-induced influence of reading order, the C-I model predicts that this strategy would facilitate the process of relating important ideas in the text. By selecting a semantically related text, a hypertext reader would be able to maintain active the relevant propositions of the document read in order to link them to the important ones in the next document (e.g. Budd, Whitney & Turley, 1995). Otherwise, as the reading distance between two related information increases, the relevant propositions first read will be deactivated and it would be harder to link them once the related propositions are read. This is the same process by which text coherence improves comprehension. However, this relation between coherence and comprehension depends on the prior knowledge of the reader (McNamara, 2001; McNamara, E. Kintsch, Songer & W. Kintsch, 1996; McNamara & Kintsch, 1996). Low knowledge readers benefit more at the situation model level from a high coherency text, whereas high knowledge readers learn more from a low coherency one. The

Appendix II

explanation for this effect is that low knowledge readers cannot fill in gaps in the incoherent text without explicit guidance about relationships among text ideas; on the other hand, expert readers who are overguided will not actively use their own prior knowledge to form the situation model of the text. In the field of hypertext comprehension, Salmerón et al. (in press) found this effect of knowledge and coherence in hypertext when comparing low and high coherency reading orders. The coherence of the reading order was measured as the semantic overlap between the content of two transited nodes (Foltz, Kintsch & Landauer, 1998). Therefore, it can be concluded that the reading order inherently followed in a hypertext has coherence properties that can affect comprehension as well as other traditional features of the text considered to affect coherence (Charney, 1994; Fritz, 1999). Following these results it could be argued that the coherence strategy would improve comprehension in hypertext mainly for low knowledge readers, but not for those with high prior knowledge. However, taking into account the possible strategic effects, the C-I model predicts that readers with prior knowledge would actively process the text in order to select the coherent order, overcoming the shallow processing induced by a high coherency text (E. Kintsch & W. Kintsch, 1995; McNamara, 2001). E. Kintsch and W. Kintsch asked participants reading a low or a high coherency text to comment on their understanding after every sentence of it. In this case, the difference for high knowledge participants found in other works (McNamara et al., 1996; McNamara & Kintsch, 1996) disappeared. Therefore, considering both the text induced and strategic influences, we could conclude that the coherence strategy would be beneficial for both readers with or without prior knowledge (see Table 1).

Second, we will analyze the interest strategy, which consists in first selecting those texts considered more interesting to the reader. Interest elicited by a hypertext node title is based on two different sources: individual and situational interest (Ainley et al., 2002). Whereas individual interest refers to the reader affinity for some stimulus or events, situational interest relates to a temporary emotional state elicited by some aspects of the situation or the text (Hidi, 2001). Although the specific contribution of each factor to topic interest is still an open question, research emphasizes the role of individual interest as the permanent source of interest during reading. By contrast, situational interest is limited to the feature that aroused that interest (e.g. the title of a particular link) and is not necessarily maintained during the entire reading session (Ainley et al., 2002). Therefore, it should be noted that the interest strategy can only be completely defined on an individual basis (i.e. considering the particular ‘individual interests’ of each person) as opposed to the coherence strategy that can be defined independently of each reader.

In regards to the text-induced effects of the interest strategy, the C-I model suggests that this strategy could hamper comprehension for low knowledge readers, because a selection not based on the semantic relation of the text would result in coherence breaks in the reading order¹. For this same reason, it could be beneficial for readers with high prior knowledge. If we focus on the possible strategic influences, the conclusions points to the same direction. Numerous works in the literature show that interest for a text can enhance its comprehension (for a recent review see Hidi, 2001). A possible explanation for this effect is that interest provides automatic attentional resources to the learning process, that otherwise need to be allocated in a controlled way (Hidi, 1990, 1995; McDaniel, Waddill, Finstad & Bourg, 2000). In addition, there is strong evidence supporting that text interest could depend on the prior knowledge of the reader (Alexander, Jetton & Kulikowich, 1995; Alexander, Kulikowich & Schulze, 1994; Garner, Alexander,

¹ For example, imagine that a reader just read a hypertext section titled ‘Effects of sunlight in air quality’, and he / she has to decide what to read next between these two sections of the same hypertext: ‘Effects of meteorology in air quality’ and ‘Negative effects of climate change in human health’. Imagine that the reader has a strong interest on topics related to ‘health’ (e.g. because he / she is a health sciences student). By following the coherence strategy, the reader would probably choose the first section on the related topic ‘Air quality’. However, by following the interest strategy, the reader would probably pick the second section due to the more interesting topic ‘Human health’. In this case, by following the interest strategy the reader would be faced with a coherence break in the reading order.

Appendix II

Gillingham, Kulikowich & Brown, 1991; Garner & Gillingham, 1991; Kintsch, 1980; Wade, Buxton & Kelly, 1999; Walker, 1981). Kintsch (1980), for example, has proposed that this relation takes the form of a U-shaped curve: at one extreme, low knowledge readers can find a new text incomprehensible and then quite boring. At the other extreme high knowledge readers can find a text redundant and therefore without interest. It is between these extremes where a text can become interesting: for intermediate knowledge readers, a text is not incomprehensible but still would present new information that can attract interest. This same relation holds for processing too. Whereas uninterested low and high knowledge readers could engage in a surface and shallow confirmatory processing respectively, interested intermediate knowledge readers could use their knowledge for constructing a more complete representation of the text (Garner & Gillingham, 1991). Others proposals in the literature suggest a linear relation between interest and prior knowledge (Tobias, 1994). In any case, more important for our present purpose is to stress that interest can be beneficial for readers with *some* prior knowledge, but not for low knowledge readers. In other words, low knowledge readers would benefit more from the coherence strategy than from the interest strategy. Research on strategy training supports this prediction (Meyer & Poon, 2001). The authors found that low knowledge readers instructed to develop a strategy for increasing text interest obtained lower learning scores than when they used a strategy intended to focus attention on structural features of a text. In the field of hypertext comprehension, previous research has found null effects of interest on text recall (Lawless, Brown, Mills & Mayall, 2003; Lawless & Kulikowich, 1998). In two experiments, the authors found that neither individual nor situational interest measured by a questionnaire was correlated with three navigational strategies (knowledge seekers, feature explorers and apathetic users, see discussion above) or to text recall. Unfortunately, the results were not reported for groups differing in prior knowledge, so we cannot conclude that the null effect held both for low and intermediate knowledge readers. In conclusion, considering both text induced and strategic influences, results in the literature suggest that the interest strategy could be beneficial for readers with prior knowledge, but not for low knowledge ones.

Table 1

Expected effects of reading strategies as a function of prior knowledge and type of influence.

	Low knowledge		Intermediate knowledge	
	Text induced	Strategic	Text induced	Strategic
Coherence st.	+		-	+
Interest st.	-	-	+	+

According to these results, an interaction could be expected between prior knowledge (low and intermediate ²) and strategy (coherence and interest) in hypertext comprehension (see Table 1): low knowledge readers learn more from the coherence strategy, whereas intermediate knowledge readers learn independently from the strategy followed. We

² Because the effect of prior knowledge in comprehension is a linear function and the effect of interest and knowledge can follow a U shaped one (although see Tobias, 1994, for arguments favoring a linear relation), we can consider that intermediate knowledge readers benefit from both effects. In addition, because in our experiments we use an Atmosphere Science text with Psychology undergraduate students, we will assume that participants with higher

Appendix II

will test these predictions in two experiments in which participants had to read an expository text in a particular hypertext that allowed us to isolate the order selection process (see description in material section). In experiment 1, we encouraged participants to read the sections in their own order, and then we analyzed their strategies a posteriori. In experiment 2, we instructed participants to read the text following a particular strategy (coherence or interest).

Experiment 1

The experimental hypotheses were as follows: (1) Participants with no prior knowledge learn more at the situation model level when following the coherence strategy than when following the interest strategy; (2) Participants with prior knowledge learn equally at the situation model level independent of the strategy used (coherence or interest).

Method

Participants

Seventy-one University of Colorado undergraduates participated for class credit.

Materials

Hypertext. An expository text on atmosphere pollution was adapted for its use in hypertext format. The text was 4,033 words long (including section titles), and was divided in 27 sections or hypertext nodes. The structure of the text consisted of four main sections (ozone depletion, greenhouse effect, air pollution and international concern on atmospheric pollution). Text readability was as follows: *Flesh Reading Ease* = 34.6; *Flesh-Kincaid Grade level* = 12. Special care was taken to assure that each node title represented as clearly as possible its content. For that purpose, node titles were written following a special procedure for analyzing the macrostructure of the text using Latent Semantic Analysis (LSA) (Kintsch, 2002). For each node, every sentence was compared with each other using the matrix comparison analysis (document to document test) and a corpus trained with encyclopedia texts. The sentence whose sum of cosines was higher was selected as the central sentence of the text. For each central sentence, every phrase was compared to the whole text on the node. The phrase with the highest cosine was chosen as the central idea of the text and was used as the title for that particular node. In some cases, the central phrase had to be slightly rewritten in order to accommodate it to a title. For example, the central phrase “The seasonal ozone depletion has been severe” was rewritten to “The severe seasonal ozone depletion”).

A hypertext was constructed in order to isolate the link selection process. The content of each node was presented one at a time on the screen, and after finishing reading it, participants could choose between only two other nodes. These two nodes were the one with the highest coherence with the previous text read, and other with the lowest coherence. Coherence between texts was computed by comparing LSA cosines for the node just read with the rest of non read nodes (the whole text of each node was used for the matrix comparison analysis, document to document test). LSA cosines provide a measure of the degree of argument overlap between texts that is assumed to reflect the level of coherence between texts (Foltz et al., 1998). The selection of the two nodes was done automatically by choosing the one with the higher and the lower LSA cosines. The links were presented one below the other. The position of the high and low coherence link was randomized across selections. Participants were not aware of the distinction between links. Each node was presented only once and it was not possible to reread it again. For example, after reading the section entitled ‘Sources of air pollutants emissions’, participants could be presented with a high related section like ‘Ground level ozone in metropolitan cities’ (with an LSA cosine of 0.73) and with a low related section such as ‘Effects of climate change in agriculture’ (LSA cosine of 0.22). In this case, a participant could use the information provided on the first read section that described ‘ground level ozone as an air pollutant’ for selecting the highly related node (another example of the link selection process can be seen in note #1). It should be noted that the procedure used here allowed us

scores in a prior knowledge questionnaire are in fact intermediate knowledge readers, not experts (high) ones.

Appendix II

to accurately identify when a reader followed the coherence strategy by analyzing the number of times the reader selected the high coherence link. However, this same logic did not follow for the interest strategy, because, as discussed in the introduction, topic interest mainly depends on the reader's preferences and therefore is not suitable for a generic procedure. For that reason, we relied on two different methods used in previous research for identifying when a reader followed the interest strategy: retrospective debriefing methodology (experiment 1) and strategy instruction (experiment 2). Therefore, the way we assessed interest was independent of the way we identified the coherence strategy. To put it in other words, we were able to identify if a participant selected a node based on the interest criterion either this node was the highest or the lowest orderly coherent.

Prior knowledge questions. Participants were given a pre-test of eight multiple choice questions to determine individual differences in domain knowledge prior to the reading phase. The test assessed general knowledge of the topic 'Atmosphere pollution,' rather than information specific to the text itself. Chance performance was 33%. Sample questions of prior knowledge and the other type of tasks are provided in Appendix A.

Inference questions. We created 10 multiple choice inference questions that required the participant to think about information located in at least two different nodes. Thus this task was intended to assess situation model comprehension. Chance performance was 33%.

Relatedness judgment task. Participants were given a list of the 14 most important concepts in the text and were instructed to rate the degree of relatedness of pairs of concepts (the combination of all concepts resulted in 91 pairs). Participants had to respond using a scale from 1 to 6, in which 1 meant high related and 6 low related. A PhD in Atmospheric Science provided expert ratings after reading the original text. We used these scores in order to compare the participants' solution with an expert one. The final score was obtained by applying the Pathfinder algorithm (Schvaneveldt, 1990) to each matrix using $r = \infty$ and $q = n-1$, and comparing the resulting Pathfinder network to the expert one. Pathfinder is a graph theoretic technique that derives network structures from proximity data. This algorithm provides a measure of the similarity between two networks called C . This value reflects the degree to which the same node in the two graphs is surrounded by a similar set of nodes. A C value of 0 corresponds to two complementary graphs and a value of 1 corresponds to equal graphs (see Dearholt & Schvaneveldt, 1990, for a detailed discussion of the Pathfinder algorithm; Acton, Johnson, & Goldsmith, 1994, and Goldsmith, Johnson, & Acton, 1991, for its use as a tool for assessing learning). The relatedness judgment task has been used successfully to assess situation model comprehension (e.g. Britton & Gülgöz, 1991).

Text-based questions. We constructed a test consisting of 22 multiple choice questions for which the question and the answer appeared in a single node and did not require the reader to infer information. Each question referred to the content of a different node. Chance performance was established at 33%.

Procedure

First participants went through a pre-test of 8 multiple choice questions assessing their domain knowledge. They were then instructed on how to use the hypertext. After that, they were required to read the text without time limit. The instructions stressed that they had to read the text carefully in order to answer a series of questions about it. Special emphasis was placed on explaining that they could only choose the order in which to read the sections, but not what sections to read (the program will only stop after having presented all the nodes). The reading procedure was as follows: first participants were presented with an introductory node with an overall description of the text. After reading a section, participants had to press a button announcing that they have finished reading the text. Then a new screen appeared presenting only two links pointing to non-read nodes. Here, participants had to click on a link for reading that particular section. After that, the selected text was presented on the screen with the button for announcing the end of the reading, but without any links. When only one node remained to be read, only one link corresponding to that text was

Appendix II

presented for selection. After reading all the nodes, participants had to perform a relatedness judgment task. Then, participants had to answer 22 multiple choice text-based questions and 10 multiple choice inference questions mixed randomly. Finally, participants were asked about the criteria they had followed for selecting the links. For each selection made ($n = 25$ because the first and last texts could not be chosen), they were presented with the title of the text they read before the selection and with the two links available after reading that text (the selected link was signaled). Participants had to answer for each selection why they chose that particular link from a series of reasons. That particular reasons have been identified in the pilot experiments presented above and were: “the link seemed the most interesting”, “the link seemed the easiest”, “the link seemed related to the previous text read”, “the link was the one on the top”, or “other reason” (in that case participants had to write the criteria followed). They were restricted to report one reason per choice.

Design

A quasi-experimental design was used with reading strategy (see below) and prior knowledge (low and intermediate) as independent variables. The two levels of prior knowledge were defined according to the median split of the answers to the eight true/false questions about the participants’ domain knowledge. The median score was 4. Participants with scores below or equal to the median were classified as low knowledge ($n = 36$, $M = 2.9$, $SD = 0.9$) and those above as intermediate knowledge ($n = 35$, $M = 5.7$, $SD = 0.9$). The dependent variables were scores on inference questions, judgment ratings and text-based questions.

Results

Analyses of reading strategies

For all experiments, differences declared as significant have $p < 0.05$ unless noted otherwise. Participants’ reading strategies were analyzed considering their declared criteria for link selection across the 25 selections. Participants were grouped under a particular reading strategy if they declared having selected a majority of links following this criterion. Three main strategies accounted for 93% of the participants: selecting the link on the top, the link most interesting or the link related to the previous text (we will refer to these strategies as first-mentioned, interest and coherence respectively). Four participants declared that they had selected the easiest links, and one that he/she made the selection randomly. Due to their small number, these five participants were excluded from the main analysis. Distribution of participants per condition can be seen in Table 2. Interestingly, most participants declared having followed more than one criterion during the experimental session. In table 3, we present the percentage of times each criterion was reported (interest, easiness, coherence, top link and other) by the group based on the declared strategy (first-mentioned, interest and coherence). The report of different criteria per strategy is particularly evident for the interest condition, which declared having followed the interest link just 48% of the time. This result could question the validity of the procedure. In order to overcome this potential problem, in experiment 2 we used a different procedure instructing participants to select the reading order following a given criterion (interest or coherence). To foreshadow, in experiment 2 we did obtain an interest group with an equivalent performance in reading order (i.e. mean LSA cosine) and learning, which supports the classification made here. In addition, previous research supports the reliability and validity of the use of this retrospective debriefing methodology for the analysis of readers’ strategies (Poulisse, Bongaerts & Kellerman, 1987). However, data obtained by this methodology should be validated against data from the reading process (Grotjahn, 1987; Taylor & Dionne, 2000). For that reason, we tested data from this grouping-by-declared strategy against three objective variables of link selection: the percentage of times that a participant selected the most coherent link, the percentage of times that he / she selected the link on the top, and the mean time participants spent deciding the reading order. A first ANOVA was conducted with reading strategy (first-mentioned, interest and coherence) as independent variable and mean LSA cosines as dependent variable. Results revealed a significant

Appendix II

difference between groups, $F(2, 63) = 50.68$, $MSe = 0.01$. Participants of the coherence group read the text in a higher coherent order ($Mean\ LSA\ cosine = 0.52$, $SD = 0.03$) than those of the interest group ($M = 0.46$, $SD = 0.04$) and of the linear group ($M = 0.42$, $SD = 0.02$), $F(1,63) = 96.27$. The interest and linear groups also differed significantly in the coherence of their transitions, $F(1,63) = 4.38$. In addition, results with percentage of top link selection as dependent variable showed a significant difference between groups, $F(2, 63) = 84.45$, $MSe = 7.26$. Participants of the first-mentioned group selected the top link more often ($Mean\ percentage = 90.59$, $SD = 10.32$) than those of the interest group ($M = 57.50$, $SD = 10.82$) and coherence groups ($M = 50.96$, $SD = 11.07$), $F(1,63) = 159.16$. The coherence and interest group were marginally different on their selection of the top link, $F(1,63) = 3.56$, $p = 0.06$. Finally, mean order decision time also differed for the three groups, $F(2, 63) = 12.19$, $MSe = 1.75$. Participants of the first-mentioned group spent less time deciding the reading order ($M = 3.3\ s$, $SD = 1.1$) than both the interest ($M = 4.7$, $SD = 1.7$) and coherence groups ($M = 5.2$, $SD = 1.1$), $F(1,63) = 21.89$. The interest and coherence groups did not differ on the time they spent deciding the reading order, $F(1,63) = 1.25$, $p < 0.3$. The three ANOVAs supported the grouping following the participant's declared strategy. Participants following the coherence condition mainly differed from those following the interest condition in that they selected the high coherent link more often. Compared to those strategies, participants following a first-mentioned criterion more often selected the top link and spent less time deciding the reading order to follow. From these results, it can be considered that participants of the first-mentioned condition chose the reading order based on a default screen position without actively analyzing the two provided links. For this reason, and following our theoretical exposition, we considered the coherence and interest as the main strategies to explore in the comprehension analyses. Notwithstanding, we also analyzed the first-mentioned condition as an ad-hoc control group to explore possible differences between passive (i.e. first-mentioned) and active strategies (i.e. coherence and interest). Learning differences with the first-mentioned condition will favor the existence of a strategic component associated with the interest or coherence strategies.

Table 2

Criterion followed for link selections as a function of strategy group.

	Strategy		
	First-mentioned	Interest	Coherence
Interest	8.63 (12.46)	47.69 (19.10)	9.00 (12.27)
Easiness	3.16 (6.34)	18.31 (16.09)	3.67 (6.45)
Coherence	2.11 (6.31)	22.92 (16.22)	81.33 (19.90)
Top link	83.79 (19.11)	10.00 (15.65)	3.50 (6.28)
Other	2.32 (7.46)	1.08 (4.74)	2.50 (4.98)

Note. Criterion data is provided in percentage. Standard deviations are provided in brackets.

Comprehension analyses

Two ANOVAs were performed with reading strategy (interest and coherence) and prior knowledge (low and intermediate) as independent variables with the two situation model measures as dependent variables. Results are summarized in Table 3. No significant main effects were found for inference questions. However, the interaction between variables was significant, $F(1, 42) = 4.2$, $MSe = 1.88$. Supporting our hypotheses, simple effects analyses revealed significant differences for low knowledge: participants following the coherence strategy scored higher than those on the interest strategy, $F(1, 42) = 4.73$; but not for intermediate knowledge, $F < 1$. In addition, scores from participants following the first-mentioned strategy were compared to the main two strategies explored. Planned comparisons between strategies for each condition of knowledge showed that the only significant difference was between low knowledge participants for the first-mentioned and coherence condition, $F(1,60) = 4.74$, $MSe = 1.72$. Low knowledge participants following the coherence strategy scored higher than low knowledge on the first-mentioned strategy.

A second ANOVA was conducted with *Pathfinder* similarity values as dependent variable. Results showed a main effect of prior knowledge, $F(1, 42) = 9.78$, $MSe = 0.01$. Participants with prior knowledge scored higher ($M = 0.32$, $SD = 0.09$) than those without ($M = 0.25$, $SD = 0.07$). In addition, the effect of strategy was closely significant, $F(1, 42) = 3.47$, $MSe = 0.01$, $p = 0.06$. Participants following the coherence strategy seem to score higher ($M = 0.31$, $SD = 0.08$) than those of the interest one ($M = 0.25$, $SD = 0.08$). More importantly, results showed a significant interaction between variables, $F(1, 42) = 4.17$, $MSe = 0.01$. Supporting our hypotheses, simple effects analyses revealed a significant difference for low knowledge participants: participants following the coherence strategy learnt more than those of the interest strategy, $F(1,42) = 7.74$; but not for intermediate knowledge, $F < 1$. Again, scores from participants following the first-mentioned strategy were compared to the main two strategies explored. As found with the inference scores, planned comparisons between strategies for each condition of knowledge showed only a close to significant difference between low knowledge participants for the first-mentioned and coherence condition, $F(1,60) = 3.59$, $MSe = 0.01$, $p = 0.06$. Low knowledge participants following the coherence strategy seem to score higher than low knowledge on the first-mentioned strategy.

Finally, an ANOVA was conducted with scores on the text-based questions as dependent variable. Results showed a main effect of prior knowledge, $F(1, 42) = 5.01$, $MSe = 9.41$. Low knowledge participants scored lower (*Mean percentage correct* = 60.53, $SD = 15.52$) than intermediate knowledge ($M = 69.46$, $SD = 12.20$). No other significant effects were found. Planned comparisons were made including participants of the first-mentioned strategy. The main effect of prior knowledge remained significant, but no other differences were found between strategies either for low knowledge participants or for intermediate knowledge.

Table 3

Mean comprehension scores as a function of prior knowledge and strategy.

	Low knowledge			Intermediate knowledge		
	First-mentioned	Interest	Coherence	First-mentioned	Interest	Coherence
Inference	33.75 (14.49)	36.36 (21.25)	50.00 (14.79)	47.50 (11.49)	54.69 (18.82)	53.13 (14.07)
Pathfinder	0.24 (0.05)	0.20 (0.04)	0.29 (0.07)	0.30 (0.05)	0.32 (0.08)	0.33 (0.10)
Text-based	59.55 (13.80)	57.02 (16.68)	64.05 (14.15)	61.82 (8.07)	67.61 (11.51)	71.31 (12.72)
n	10	11	11	10	8	16

Note. Inference and text-based scores are reported in percentage of correct answers. Ratings are reported in the Pathfinder C similarity value, which scores range from 0 to 1. Standard deviations are provided in brackets.

Reading time analyses

Additional analyses were conducted including strategy and prior knowledge in order to assess the time spend reading the texts. Participant's reading times were measured in seconds for each section. Reading time was divided by the number of words in the section, yielding an average time spend per word. Mean reading times were significantly different only for the strategy conditions, $F(2, 60) = 3.57$, $MSe = 0.01$. Participants of the first-mentioned condition spend less time reading the texts ($M = 0.21$ s/word, $SD = 0.06$) than those of the coherence condition ($M = 0.27$, $SD = 0.06$), $F(1,60) = 7.07$, but they did not differ from the interest condition ($M = 0.25$, $SD = 0.09$), $F(1,60) = 2.63$, $p < 0.15$. There were no differences between the coherence and interest condition, $F < 1$.

Discussion

The data of experiment 1 supports the result found in the pilot studies presented above showing that coherence is not the only reading strategy followed by hypertext readers, as suggested by the Strategy Competition Model (Foltz, 1996; Goldman & Saul, 1990). 38% of the participants report they followed the coherence strategy, 27% the interest strategy and 28% chose the link presented on the top. Therefore, coherence and interest can be considered as two main strategies followed by hypertext readers (Ainley et al., 2002; Foltz, 1996). As already observed above, the selection of a particular strategy can depend on characteristics of both hypertext and readers, so the identification of other important strategies and the features that induce to follow a particular strategy is open to future research. In addition, the results support the hypothesis that reading strategies affect hypertext comprehension, and that this effect interacts with the prior knowledge of the reader (Salmerón et al., in press). On the one hand, low knowledge reader's comprehension is higher when they select a text-coherent reading order than when they select the most interesting texts (Budd et al., 1995; Meyer & Poon, 2001). On the other hand, comprehension for readers with some prior knowledge is similar when participants follow the coherence and the interest strategy. These results are supported by two situation model measures: inference questions and relatedness judgment ratings. In addition, the same pattern of results is observed when the coherence and interest strategy is compared to a non active selection of the order (i.e. first-mentioned condition). For low knowledge the coherence strategy remains the better, and for intermediate knowledge there are no differences

Appendix II

between strategies. In addition, text-based results show no differences for reading strategies. This concurs with prior research on hypertext comprehension (Salmerón et al., in press). The authors have found that the text reading order inherent to different reading strategies does not necessarily influence scores on text-based questions. On the contrary, they depend on the number of different sections of the hypertext that were read. Put in other words, a strategy leading to read a major number of nodes increases scores on text-based questions (Salmerón et al., in press; see also Kintsch & Yarbrough, 1982). Because in experiment 1 participants have to read all nodes, no differences for this variable were expected.

Results from the first-mentioned condition can be considered as a starting point to explore the nature of the effects on comprehension of hypertext strategies (strategic or text-induced). The logic for the comparisons is based on the fact that the first-mentioned condition lacks the active strategic component associated to a reasoned selection of the reading order. Therefore, the fact that for intermediate knowledge the interest strategy shows similar results to the first-mentioned condition suggests that the effect of the interest strategy is merely based on the low coherence reading order associated to it (i.e. a text-induced effect). This result is apparently contradictory to prior literature, which shows a strategic benefit of interest for intermediate knowledge readers (Alexander et al., 1995; Garner & Gillingham, 1991). Unfortunately, the first-mentioned condition does not allow for distinguishing between the text-induced and strategic effects of the coherence strategy because both conditions not only differ on the strategic component but also on the reading order (low and high coherent). Therefore, a complete exploration of the nature of the effects of hypertext strategies must wait until the appropriate experimental conditions are considered in experiment 2.

Experiment 2

A first objective of experiment 2 was to replicate the effects found on experiment 1 with a different methodology. In addition, in experiment 2 we explored in depth the nature of the effects on comprehension of hypertext reading strategies. For that purpose we included two non-strategic conditions meant to isolate the potential strategic effects of the coherence and interest strategies. In one of these non-strategic conditions, participants read (without choice of order) the text linearly presented in a high coherence order and, in the other, they read the text presented in a low coherence order. Two comparisons were planned: the high coherence non-strategic condition versus the coherence strategy, and the low coherence non-strategic condition versus the interest strategy. In both cases participants would read the text in the same reading order (high or low coherent respectively), which would allow controlling for the text-induced effects. Therefore, any difference found in these comparisons will support the existence of a strategic component associated with the fact that readers had to decide their own reading order (i.e. interest or coherence strategy). In addition to the hypotheses explored in experiment 1, in experiment 2 we considered two new hypotheses derived from the theoretical assumptions discussed in the introduction: (1) ‘Text-induced influence for low knowledge’: participants with no prior knowledge following the coherence strategy learn equal to those of the non-strategic high coherence order condition, and participants with no prior knowledge following the interest strategy get learning outcomes similar to those of the non-strategic low coherence order condition. (2) ‘Strategic influence for intermediate knowledge’: participants with prior knowledge following the coherence strategy learn more than those of the non-strategic high coherence order condition, and participants with prior knowledge following the interest strategy get higher learning outcomes than those of the non-strategic low coherence order condition.

Method

Participants

One hundred fifty-two University of Colorado undergraduates participated for class credit.

Materials

Appendix II

For the reading strategy group the materials were the same as used in experiment 1. For the non-strategic group, two different text conditions were created, one in which the sections were ordered so that the coherence between transitions was as low as possible, and other in which the sections were ordered so that the coherence between transitions was as high as possible. This was done by arranging the sections in an order in which the sum of LSA cosines between texts was the lowest or the highest possible, respectively. Comprehension tasks were the same as used in experiment 1.

Procedure

The only change in the procedure was the instructions provided to participants. For the reading strategy group, participants in the coherence condition were told to select the link that seemed more related to the content of the text immediately preceding it, whereas participants in the interest condition were instructed to select the link that seemed more interesting. In the non-strategic group, participants were provided with only one link each time, so they were not able to choose the reading order. Instructions told them to select the link presented after reading each section.

Design

A between groups design was used with reading strategy (interest and coherence) and prior knowledge (low and intermediate) as independent variables. We established a non-strategic condition for each reading strategy (i.e. low coherence order for the interest strategy, and high coherence order for the coherence strategy). The two levels of prior knowledge were defined according to the median split of the answers to the eight questions about the participants' domain knowledge. The median score was 4. Participants with scores below or equal to the median were classified as low knowledge ($n = 89$, $M = 3$, $SD = 0.9$) and those above as intermediate knowledge ($n = 63$, $M = 5.6$, $SD = 0.9$). The distribution of participants per condition is reported in table 4. The dependent variables were scores on inference questions, judgment ratings and text-based questions.

Results

Analyses of reading strategies

In order to check the validity of the strategy instruction procedure used here we compared the mean LSA cosine and decision order time of the strategic group (coherence and interest) by prior knowledge (low and intermediate). Results revealed only a main effect of type of strategy, $F(1, 72) = 54.23$, $MSe = 0.01$. Similar to results in experiment 1, participants in the coherence strategy condition read the text in a higher coherency order ($Mean\ LSA\ cosine = 0.52$, $SD = 0.03$) than those in the interest strategy condition ($M = 0.46$, $SD = 0.03$). In addition, the time participants spent selecting the reading order did not differ between conditions ($F(1, 72) = 2.69$, $MSe = 3.34$, $p < 0.15$ for the interaction). Therefore, the reading strategy group (coherence and interest) was considered for the following analyses.

Comprehension analyses

Prior to considering our hypotheses, we analyzed comprehension outcomes from the non-strategic group (low and high coherence) in order to check these results with prior research on the role of coherence order (Salmerón et al., in press; Schnotz, 1982). For that purpose, we performed a set of ANOVAs with the non-strategic group (low and high coherence) and prior knowledge (low and intermediate) as independent variables, and the three comprehension scores as dependent variables. Results from the inference questions revealed only a significant interaction, $F(1, 72) = 8.83$, $MSe = 2.12$. Supporting prior research, follow up comparisons showed that low knowledge readers tended to learn more with the high coherence order than with the low coherence, $F(1, 72) = 3.84$, $p = 0.05$, whereas intermediate knowledge showed the opposite pattern, $F(1, 72) = 5.05$. Similar results were found for the Pathfinder similarities. Only the interaction between variables was significant, $F(1, 72) = 7.66$, $MSe = 0.01$. Again, low knowledge readers seemed to benefit more with the high coherence order than with the low coherence, $F(1, 72) = 3.85$, $p = 0.05$, whereas the

Appendix II

opposite was found for intermediate knowledge, $F(1, 72) = 4.06$. There were no differences for the text-based questions ($F < 1$ for the interaction).

In order to assess hypotheses regarding the effect of strategies and prior knowledge on comprehension (i.e. the same explored in experiment 1), a set of ANOVAs was performed with strategy (coherence and interest) and prior knowledge (low and intermediate), using the different comprehension scores as dependent variables (Table 4). Inference scores showed only an interaction between variables, $F(1, 72) = 4.48$, $MSe = 1.67$. Supporting our hypotheses, simple effects analyses revealed that participants in the coherence strategy condition outperformed those in the interest condition for low knowledge, $F(1, 72) = 6.97$, but not for intermediate knowledge, $F < 1$. A similar pattern was found for the Pathfinder similarities. There was a main effect of prior knowledge, $F(1, 72) = 4.03$, $MSe = 0.01$. Low knowledge scored lower ($M = 0.27$, $SD = 0.07$) than intermediate knowledge ($M = 0.3$, $SD = 0.07$). There was no effect of strategy. However, the interaction between variables was significant, $F(1, 72) = 4.69$, $MSe = 0.01$. Again, simple effects analyses revealed that participants in the coherence strategy condition learned more than those in the interest group for low knowledge, $F(1, 72) = 5.68$, but not for intermediate knowledge, $F < 1$. No differences were found for the text-based questions ($F < 1$ for the interaction).

Finally, in order to assess hypotheses regarding the nature of the effects on comprehension of reading strategies (strategic or text induced), we conducted a series of planned comparisons (Rosenthal & Rosnow, 1985). For each strategy (interest and coherence) and prior knowledge (low and intermediate), we made a comparison with its corresponding non-strategic condition (low and high coherence respectively). If a comparison failed to reveal differences, we could assume that the comprehension effect of a particular strategy is due mainly to the text induced effect of reading order (as predicted for low knowledge readers). By contrast, if a comparison revealed a significant difference, it would support the claim that the comprehension effect for this particular strategy is independent of that induced by the reading order (as predicted for intermediate knowledge readers). Supporting hypothesis 1 'Text-induced influence for low knowledge', no comparison was significant for low knowledge ($F < 1$ both for the interest and coherence strategy, and for both dependent variables inference and Pathfinder scores). Similarly, no differences were found for the comparisons for the interest strategy for intermediate knowledge ($F < 1$ for both inference and Pathfinder scores). However, supporting hypothesis 2 'Strategic influence for intermediate knowledge', planned comparisons showed a significant difference for the coherence strategy for intermediate knowledge, $F(1, 144) = 5.08$, $MSe = 1.89$ for the inference scores and $F(1, 144) = 4.01$, $MSe = 0.01$ for the Pathfinder similarities. Intermediate knowledge participants following the coherence strategy learned more than those reading linearly a high coherence ordered text without link selection (Figures 1 and 2).

Table 4

Mean comprehension scores as a function of prior knowledge and strategy.

	Control				Strategic			
	Low Knowledge		Intermediate Knowledge		Low Knowledge		Intermediate Knowledge	
	Low Coherence	High Coherence	Low Coherence	High Coherence	Interest	Coherence	Interest	Coherence
Inference	41.76 (20.97)	53.42 (20.75)	52.38 (28.79)	34.29 (10.53)	37.82 (14.23)	53.42 (17.35)	53.06 (23.54)	50.48 (16.08)
Pathfinder	0.25 (0.08)	0.30 (0.07)	0.30 (0.08)	0.24 (0.07)	0.24 (0.08)	0.30 (0.07)	0.31 (0.07)	0.29 (0.09)
Text-based	56.64 (18.64)	60.48 (14.98)	62.88 (17.21)	60.30 (19.92)	60.51 (10.17)	59.25 (12.70)	59.07 (14.72)	61.67 (17.58)
n	26	23	12	15	17	23	21	15

Note. Inference and text-based scores are reported in percentage of correct answers. Ratings are reported in the Pathfinder C similarity value, which scores range from 0 to 1. Standard deviations are provided in brackets.

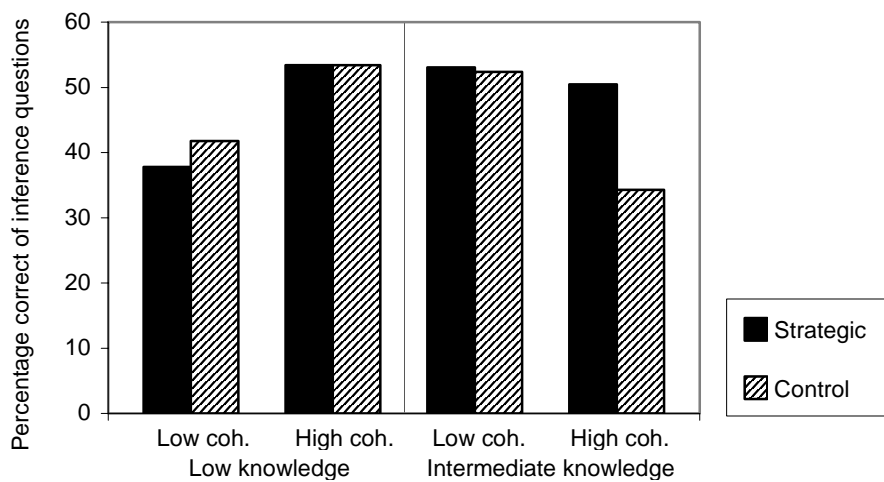


Figure 1. Percentage of correct inference questions as a function of type of task, prior knowledge and text order coherence.

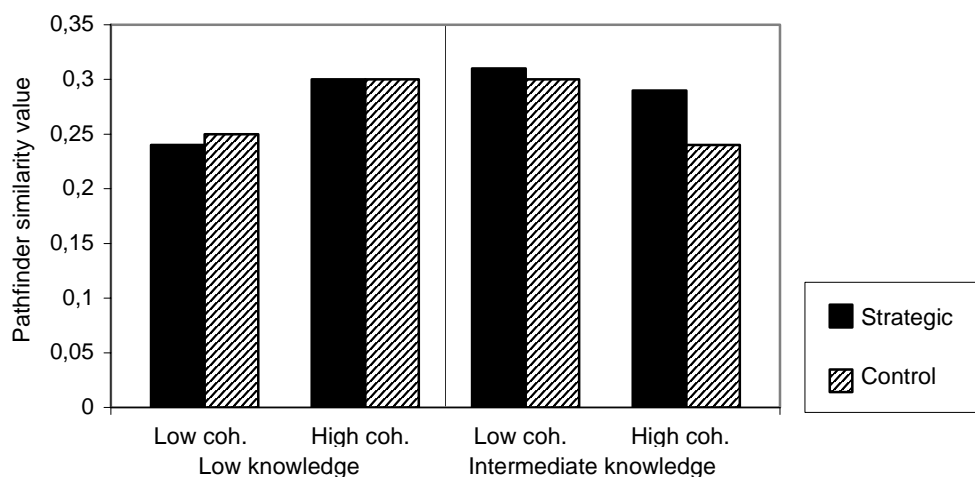


Figure 2. Judgment relatedness scores (reported on the Pathfinder similarity value) as a function of type of task, prior knowledge and text order coherence.

Reading times analyses

A possible influence of reading times was explored for the strategic and non-strategic groups by prior knowledge. Participant's reading times were measured in seconds for each section. Reading time was divided by the number of words in the section, yielding an average time spend per word. None of the effects were significantly reliable ($F < 1$ for the 3-way interaction).

Discussion

Results of experiment 2 replicate the main effects found in experiment 1 using a different experimental methodology. Low knowledge learn more from following the coherence strategy than the interest strategy. In contrast, intermediate knowledge learn equally from both strategies. In addition, the results of experiment 2 allow us to clarify the nature of the comprehension effects of the different strategies. Comprehension for low knowledge readers following the coherence or interest strategy is similar to those just following a high or low coherence order without link selection. Therefore, for novice readers the effect of reading strategies seems to be based merely on their indirect effect on the text order coherence (Salmerón et al., in press; Schnotz, 1982). For readers with some prior knowledge, results of experiment 2 show a strategic effect for the coherence strategy, but fail to show a similar effect for the interest strategy³. Intermediate knowledge participants instructed to follow the coherence strategy learned more than those reading the text in a high coherence order without link selection. This effect is consistent with the literature of coherence and prior knowledge. On the one hand, when readers with intermediate knowledge read a high coherence text they do not need to engage in deep processing in order to understand the text, and, as a consequence, their learning will drop compared to when they read a more challenging text (e.g. a low coherence text) (McNamara, 2001; McNamara et al., 1996; McNamara & Kintsch, 1996). This seems to be the case for the condition reading a high coherent order text without link selection (non-strategic high coherence order). On the other hand, when readers with some prior knowledge are

³ An alternative explanation for the null effects between the coherence and interest strategies for intermediate knowledge is that they simply had less to learn from the text, because they knew more at the beginning of the study. However, this explanation has two drawbacks. First, prior knowledge is measured in both experiments with a text on basic issues on the topic of the text, rather than on content of the text itself that is more specific. Therefore, as most experiments using the prior knowledge manipulation we assume that intermediate knowledge know some basis on the text topic, but not the details on it. Second, there are differences for intermediate knowledge between conditions that can not be explained by this interpretation. Concretely, intermediate knowledge learn less when they read a high coherence ordered text without node selection (i.e. non-strategic high coherence condition of experiment 2) than on

Appendix II

instructed to process the text actively, they can overcome the otherwise shallow processing induced by a high coherence text (E. Kintsch & W. Kintsch, 1995; McNamara, 2001). Participants in the coherence strategy condition read the text in a high coherent order, but the selection of the high related text induce them to engage in a more active processing of the text. By contrast, participants of experiment 2 instructed to follow the interest strategy comprehended the text at the same level as those who read the text in a low coherent order without link selection. This result fails to support the claim that interest improves comprehension for intermediate knowledge readers (Alexander et al., 1995; Garner & Gillingham, 1991). However, a closer look at the mechanisms by which intermediate people comprehend a text can help to clarify these apparently contradictory results. Readers with some prior knowledge will improve their comprehension by activating their existing knowledge and linking it to the ideas expressed in the text (Kintsch, 1994). Therefore, the critical issue is to evaluate the situations in which intermediate readers process the text actively independent of whether this activation comes from the text (e.g. low coherency text) or from the strategy (e.g. high reading skills, coherence strategy). For example, in concurrence with the present findings, O'Reilly and McNamara (2002) have found that readers with some prior knowledge can overcome the negative effects of a high coherency text if they possess high reading skills. In our case, activation of participants in the non-strategic low coherence order condition is induced by the necessity of clarifying the coherence breaks in the text. In addition, activation of participants following the interesting link could come from the coherence breaks (LSA cosines for reading order are significantly lower for this strategy than for the coherence strategy), the induced topic interest (Hidi, 1990, 1995; McDaniel et al., 2000), or a combination of both. Unfortunately, for the interest strategy it is hard to isolate text induced and strategic effects. For that purpose, we need to control for the coherence order effects, i.e. a condition instructed to select first the most interesting parts (i.e. interest strategy), that at the same time presents the different parts in a high coherency order. This procedure seems implausible because text coherence is a property of the text, but text interest depends on the participant. We can, however, positively conclude that the interest strategy promotes learning for intermediate knowledge at the same level as the coherence strategy does.

Conclusions

We reported two studies that examined the relation between prior knowledge and reading strategies in learning from hypertext. Following, we will summarize the results that provided clear insights on this relation. Next we will discuss some possible interrelations between the coherence and the interest strategies. Finally, we will discuss our results trying to resolve inconsistencies in the literature concerning whether hypertext supports better comprehension than traditional linear texts.

Reading strategies, prior knowledge and hypertext learning

Results from two experiments support the claim that hypertext readers follow different criteria in order to select the reading order of the text and that these have distinct effects on comprehension depending on the reader's prior knowledge. The two main strategies consist in selecting the link semantically related to the previously read (Foltz, 1996) and of choosing the most interesting links delaying the selection of the less interesting (Ainley et al., 2002). A third criterion consisted in the selection of the link based on a default screen position. For low knowledge readers, the coherence strategy supported better learning of the text (Meyer & Poon, 2001). The nature of this effect seems to rely on the improvement of text order coherence induced by this strategy. By contrast, for intermediate knowledge, both the coherence and interest strategy benefited comprehension equally. In the case of the coherence strategy, this benefit was supported through the active processing induced by the selection of the high coherence links. In the case of the interest strategy, the learning benefit could be associated with the combined effects from an increase in the automatic attention

the other conditions.

Appendix II

devoted to the comprehension process (Hidi, 1990, 1995; McDaniel et al., 2000) and from the coherence breaks in the induced reading order by the strategy.

Relation between coherence and interest strategies

In this work we have assumed that the coherence and interest strategies are independent, but this assumption requires some consideration. For example, a reader mainly selecting the high coherency link might also be selecting sometimes an interesting link. Or a reader mainly selecting the most interesting link might also sometimes select at the same time a link with argument overlap (even though the reader is not aware of the semantic relation). This overlap between the coherence and interest strategies is possible due to its different nature: whereas coherence is a feature of the text, interest depends on the reader. In addition, we should also consider the possible interdependences between both strategies. As described in the introduction, interest for a title node comes from both individual (i.e. permanent) and situational (i.e. text induced) interest. Individual interest depends on the reader's affinities and therefore is independent of text coherence. However, situational interest for a title node can be influenced by some features of the text, including text coherence (Schraw, 1997; Schraw, Bruning & Svoboda, 1995). The authors found that reported situational interest on a text was positively correlated to reported 'ease of processing' of the same text. Unfortunately, no experimental manipulation of text coherence was made, so the direction of the relation is tentative. In our context, these results could suggest either that participants selecting the high coherence link will also develop some situational interest for the title node or vice versa. Therefore, the important question here is to evaluate to which extent this issue limits the validity of the procedure and the theoretical implications of our experiments. In experiment 1, participants reported the criterion they followed for each of the 25 selections between nodes. We can not know if they simultaneously considered both coherence and interest for making their choice because they were restricted to only one criterion per choice. However, in experiment 2 readers were instructed to follow either the most coherent link or the most interesting link. Therefore, if either coherence promoted interest or vice versa, participants on both conditions should have followed similar reading orders. Contrary to that prediction, participants on the coherence condition read the text in a higher coherency order than those on the interest condition (measured by the LSA cosine between texts transited). Therefore, we agree that both coherence and interest strategies can overlap to some extent. However, we believe that results from reading order measures and learning performance (e.g. differences between strategies for low knowledge readers) support our claim that both strategies independently affect hypertext comprehension.

Is hypertext a good alternative to linear texts for promoting learning?

The results from both experiments can also be considered in order to explore the benefits and drawbacks of hypertext and linear text. It should be noted that we restrict our analysis to a main feature of hypertext, mainly the selection of reading order. Early proposals in the literature of hypertext comprehension claimed that hypertext could improve learning compared to a linear version of the text. The rationale was that mapping the semantic structure of the text onto the hypertext links would result in greater improvements in the reader's mental representation of the text (e.g. Jonassen, 1993; McDonald, Paap & McDonald, 1990). However, more than a decade of research has failed to support this claim (Dillon & Gabbard, 1998; Unz & Hesse, 1999). The distinction proposed here between the strategic and text induced effects of reading strategies in hypertext can be useful for determining when a hypertext can be more helpful than a linear text: if there is a strategic effect associated to the selection of reading order, it could be concluded that hypertext would be beneficial. Overall, results support the claim that hypertext can be beneficial for readers with prior knowledge, particularly when they are induced to actively select the reading order (e.g. by using embedded links into the text instead of explicit overviews of the content). This benefit is related to the processes by which readers with prior knowledge comprehend a text. When they engage in an active processing of the text, they are able to use their prior knowledge in order to construct a more coherent representation of it (W. Kintsch, 1994; E. Kintsch & W. Kintsch,

Appendix II

1995; McNamara, 2001). However, it has to be noted that a reader with prior knowledge will learn equally from a hypertext and a linear text if they process the text in an active manner. In addition, results reveal that hypertext is not particularly beneficial for low knowledge readers. This is due to the fact that for low knowledge readers the selection order does not affect comprehension strategically, but indirectly through the changes in the coherence of the reading order associated to a particular strategy. In the best scenario, low knowledge readers selecting the order when trying to establish global text coherence will learn the same as those reading linearly a high coherence version of the text. But when choosing other particular criterion for the order selection (i.e. interest or screen position), breaks in text coherence would hamper their comprehension (Charney, 1994; Fritz, 1999). Therefore, a critical issue for low knowledge readers using a hypertext as a way of learning is to identify what makes a reader select the order in a coherent manner. A possible explanation can be related to their reading monitoring skills (e.g. Roberts & Newton, 2001). When a reader decides to choose the links following a strategy inducing breaks in the text coherence (i.e. interest or screen position), he / she would experience comprehension problems that ultimately could lead him / her to change to the coherence strategy. However, in order to do that the reader has to realize that his / her comprehension of the text presented in the hypertext is not optimal, a phenomenon that can be related to his / her monitoring skills (Bannert, 2003; Hill & Hannafin, 1997; Schmidt & Ford, 2003). Therefore, it could be argued that low knowledge readers with high monitoring skills will tend to avoid the strategies inducing breaks in text coherence.

References

- Acton, W. H., Johnson, P. J., & Goldsmith, T. E. (1994). Structural knowledge assessment: Comparison of referent structures. *Journal of Educational Psychology, 86*, 303-311.
- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 545-561.
- Alexander, P. A., Jetton, T. L. & Kulikowich, J. M. (1995). Interrelationship of knowledge, interest, and recall: assessing a model of domain learning. *Journal of Educational Psychology, 87*, 559-575.
- Alexander, P. A., Kulikowich, J. M. & Schulze, S. K. (1994). How subject-matter knowledge affects recall and interest. *American Educational Research Journal, 31*, 313-337.
- Anderson-Inman, L., & Horney, M. A. (1994). The electrotext project: Hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia, 3*, 71-91.
- Bannert, M. (2003). Effekte metakognitiver Lernhilfen auf den Wissenserwerb in vernetzten Lernumgebungen [Effects of Metacognitive Help on Knowledge Acquisition in Web-based Learning Environments]. *Zeitschrift für Pädagogische Psychologie, 17*, 13-25.
- Barab, S. A., Bowdish, B. E., & Lawless, K. A. (1997). Hypermedia navigation: profiles of hypermedia users. *Educational Technology Research and Development, 45*, 23-42.
- Barab, S. A., Bowdish, B. E., Young, M. F., & Owen, S. V. (1996). Understanding kiosk navigation: using log files to capture hypermedia searches. *Instructional Science, 24*, 377-395.
- Barab, S. A., Fajen, B. R., Kulikowich, J. M. & Young, M. F. (1996). Assessing hypertext navigation through Pathfinder: prospects and limitations. *Journal of Educational Computing Research, 15*, 185-205.
- Barab, S. A., Young, M. F., & Wang, J. (1999). The effects of navigational and generative activities in hypertext learning on problem solving and comprehension. *International Journal of Instructional Media, 26*, 283-309.
- Britt, M.A., Rouet, J.-F., & Perfetti, C.A. (1996). Using hypertext to study and reason about historical evidence. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 43-72). Mahwah, NJ: Lawrence Erlbaum Associates.

Appendix II

- Britton, B. K., & Gülgöz, S. (1991). Using Kintsch's computational model to improve instructional text: Effects of inference calls on recall and cognitive structures. *Journal of Educational Psychology*, 83, 329-345.
- Budd, D., Whitney, P., & Turley, K. J. (1995). Individual differences in working memory strategies for reading expository text. *Memory & Cognition*, 23, 735-748.
- Charney, D. (1994). The impact of hypertext on processes of reading and writing. In S. J. Hilligoss & C. L. Selfe (Eds.), *Literacy and Computers*. New York: MLA.
- Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, R., & Glaser, R. (1989). Self-explanation: How students study and use examples in learning to solve problems. *Cognitive Science*, 13, 145-182.
- Chi, M. T. H., De Leeuw, M., Chiu, M., & LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, 18, 439-477.
- Danner, F. W. (1976). Children's understanding of intersentence organization in the recall of short descriptive passages. *Journal of Educational Psychology*, 68, 174-183
- Dearholt, D. W. & Schvaneveldt, R. W. (1990). Properties of pathfinder networks. In R. W. Schvaneveldt (Ed.), *Pathfinder associative networks: Studies in knowledge organization*, (pp. 1-30). Norwood, NJ: Ablex.
- Dillon, A. (1991). Readers' models of text structures: The case of academic articles. *International Journal of Man-Machine Studies*, 35, 913-925.
- Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, 68, 322-349.
- Foltz, P. W. (1996). Comprehension, coherence, and strategies in hypertext and linear text. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 109-136). Mahwah, NJ: Lawrence Erlbaum Associates.
- Foltz, P. W., Kintsch, W., & Landauer, T. K. (1998). The measurement of textual coherence with Latent Semantic Analysis. *Discourse Processes*, 25, 285-307.
- Fritz, G. (1999). Coherence in hypertext. In W. Bublitz, U. Lenk & E. Ventola (Eds.), *Coherence in spoken and written discourse: how to create it and how to describe it* (pp. 221-232). Amsterdam, Philadelphia: John Benjamins.
- Garner, R., Alexander, P. A., Gillingham, M., Kulikowich, & Brown, R. (1991). Interest and learning from text. *American Educational Research Journal*, 28, 643-659.
- Garner, R., & Gillingham, M. (1991). Topic knowledge, cognitive interest, and text recall: a microanalysis. *Journal of Experimental Education*, 59, 310-319.
- Goldman, S. R., & Saul, E. (1990). Flexibility in text processing: a strategy competition model. *Learning and Individual Differences*, 2, 181-219.
- Goldman, S. R., Saul, E., & Coté, N. (1995). Paragraphing, reader, and task effects on discourse comprehension. *Discourse Processes*, 20, 273-305.
- Goldsmith, T. E., Johnson, P. J., & Acton, W. H. (1991). Assessing structural knowledge. *Journal of Educational Psychology*, 83, 88-96.
- Grotjahn, R. (1987). On the methodological basis of introspective methods. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 54-81). Philadelphia: Multilingual Matters, Ltd.
- Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research*, 60, 549-571.
- Hidi, S. (1995). A re-examination of the role of attention in learning from text. *Educational Psychology Review*, 7, 323-350.

Appendix II

Hidi, S. (2001). Interest, reading, and learning: theoretical and practical considerations. *Educational Psychology Review*, 13, 191-209.

Hill, J. R., & Hannafin, M. J. (1997). Cognitive strategies and learning from the World Wide Web. *Educational Technology Research and Development*, 45, 37-64.

Horney, M. A., & Anderson-Inman, L. (1994). The electrotext project: hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia*, 3, 71-91.

Jonassen, D. H. (1993). Effects of semantically structured hypertext knowledge bases on users' knowledge structures. In C. McKnight, A. Dillon & J. Richardson (Eds.), *Hypertext: A psychological perspective*, (pp. 153-168). New York: Ellis Horwood.

Kintsch, E., & Kintsch, W. (1995). Strategies to promote active learning from text: individual differences in background knowledge. *Swiss Journal of Psychology*, 54, 141-151.

Kintsch, W. (1980). Learning from text, levels of comprehension, or: why anyone would read a story anyway? *Poetics*, 9, 87-98.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, 95, 163-182.

Kintsch, W. (1994). Text comprehension, memory, and learning. *American Psychologist*, 49, 294-303.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.

Kintsch, W. (2002). On the notions of theme and topic in psychological process models of text comprehension. In M. Louwse, & V. Peer. *Thematics: Interdisciplinary studies* (pp. 157-170). Amsterdam, Netherlands: John Benjamins Publishing Company.

Kintsch, W., & Yarbrough, J. C. (1982). The role of rhetorical structure in text comprehension. *Journal of Educational Psychology*, 74, 828-834.

Lawless, K. A., Brown, S. W., Mills, R., & Mayall, H. J. (2003). Knowledge, interest, recall and navigation: a look at hypertext processing. *Journal of Literacy Research*, 35, 911-934.

Lawless, K. A., & Kulikowich, J. M. (1996). Understanding hypertext navigation through cluster analysis. *Journal of Educational Computing Research*, 14, 385-399.

Lawless, K. A., & Kulikowich, J. M. (1998). Domain knowledge, interest, and hypertext navigation: a study of individual differences. *Journal of Educational Multimedia and Hypermedia*, 7, 51-70.

Lawless, K. A., Mills, R., & Brown, S. W. (2002). Children's hypermedia navigational strategies. *Journal of Research on Computing in Education*, 34, 274-284.

Lodewijks, H. (1982). Self-regulated versus teacher-provided sequencing of information in learning from text. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 509-520). Amsterdam: North-Holland.

Magliano, J. P., Trabasso, T. & Graesser, A. C. (1999). Strategic processing during comprehension. *Journal of Educational Psychology*, 91, 615-629.

Mayer, R. E. (1976). Some conditions of meaningful learning for computer programming: advance organizers and subject control of frame order. *Journal of Educational Psychology*, 68, 143-150.

McDaniel, M. A., Waddill, P. J., Finstad, K., & Bourg, T. (2000). The effects of text-based interest on attention and recall. *Journal of Educational Psychology*, 92, 492-502.

McDonald, J. E., Paap, K. R., & McDonald, D. R. (1990). Hypertext perspectives: Using Pathfinder to build hypertext systems. In R. W. Schvaneveldt (Ed.), *Pathfinder associative networks: studies in knowledge organization* (pp. 197-212). Norwood, NH: Ablex.

McNamara, D. S. (2001). Reading both high-coherence and low-coherence texts: Effects of text sequence and

Appendix II

prior knowledge. *Canadian Journal of Experimental Psychology*, 55, 51-62.

McNamara, D. S. (2004). SERT: self-explanation reading training. *Discourse Processes*, 38, 1-30.

McNamara, D. S., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interaction of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1-42.

McNamara, D. S., & Kintsch, W. (1996). Learning from text: effect of prior knowledge and text coherence. *Discourse Processes*, 22, 247-288.

McNamara, D. S., & Scott, J. L. (1999). Training reading strategies. *Proceedings of the Twenty-first Annual Meeting of the Cognitive Science Society* (pp. 387-392). Hillsdale, NJ: Lawrence Erlbaum Associates.

Meyer, B., & Poon, L. W. (2001). Effects of structure strategy training and signaling on recall of text. *Journal of Educational Psychology*, 93, 141-159.

Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, 23, 237-255.

O'Reilly, T., & McNamara, D. S. (2002, November). *Good texts can be better for active readers?* Poster presented at the 43rd annual meeting of the Psychonomic Society Inc., Kansas City.

Poullisse, N., Bongaerts, T., & Kellerman, E. (1987). The use of retrospective verbal reports in the analysis of compensatory strategies. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 213-299). Philadelphia: Multilingual Matters, Ltd.

Pressley, M., Symons, S., McDaniel, M. A., Snyder, B. L., & Turnure, J. E. (1988). Elaborative interrogation facilitates acquisition of confusing facts. *Journal of Educational Psychology*, 80, 268-278.

Roberts, M. J., & Newton, E. J. (2001). Understanding strategy selection. *International Journal of Human-Computer Studies*, 54, 137-154.

Rosenthal, R. & Rosnow, R. L. (1985). *Contrast analysis. Focused comparisons in the analysis of variance*. New York: Cambridge University Press.

Rouet, J.-L., Favart, M., Britt, M. A. & Perfetti, C. A. (1997). Studying and using multiple documents in history: Effects of discipline expertise. *Cognition & Instruction*, 15, 85-106.

Salmerón, L., Cañas, J. J., Kintsch, W., & Fajardo, I. (in press). Reading strategies and hypertext comprehension. *Discourse Processes*.

Schnotz, W. (1982). How do different readers learn with different text organizations? In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 87-97). Amsterdam: North-Holland.

Schnotz, W. (1984). Comparative instructional text organization. H. Mandl, N. L. Stein, & T. Trabasso (Eds.), *Learning and comprehension of text* (pp. 53-81). Hillsdale, N. J.: Lawrence Erlbaum Associates.

Schnotz, W. (1993). Adaptive construction of mental representations in understanding expository texts. *Contemporary Educational Psychology*, 18, 114-120.

Schmidt, A. M., & Ford, J. K. (2003). Learning within a learner control training environment: The interactive effects of goal orientation and metacognitive instruction on learning outcomes. *Personnel Psychology*, 56, 405-429.

Schraw, G. (1997). Situational interest in literary text. *Contemporary Educational Psychology*, 22, 436-456

Schraw, G., Bruning, R. & Svoboda, C. (1995). Sources of situational interest. *Journal of Reading Behavior*, 27, 1-17

Schvaneveldt, R. (Ed.) (1990). *Pathfinder associative networks: studies in knowledge organization*. Norwood, NJ: Ablex.

Taylor, K. L., & Dionne, J. P. (2000). Accessing problem-solving strategy knowledge: the complementary use

Appendix II

of concurrent verbal protocols and retrospective debriefing. *Journal of Educational Psychology*, 92, 413-425.

Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research*, 64, 37-54.

Trabasso, T., & Magliano, J. P. (1996). Conscious understanding during text comprehension. *Discourse Processes*, 21, 255-288.

Unz, D. C., & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, 20, 279-295.

Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.

Wade, S. E., Buxton, W. M., & Kelly, M. (1999). Using think-alouds to examine reader-text interest. *Reading Research Quarterly*, 34, 194-216.

Wagner, R. K. & Sternberg, R. J. (1987). Executive control in reading comprehension. In B. K. Britton & S. M. Glynn (Eds.), *Executive control processes in reading*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Walker, W. H. (1981). *Interest as a function of knowledge*. (Tech. Rep. No. 109). Boulder, CO: University of Colorado, Institute of Cognitive Science.

Appendix A

Prior Knowledge Question

The Montreal Protocol is accepted by nations agreeing to restrict the release of:

- A. Ozone depleting chemicals. (correct)
- B. Greenhouse gases.
- C. Climate change chemicals.

Text-based Question

Human activity specially affects:

- A. The four layers of the atmosphere.
- B. The two layers of the atmosphere closest to the earth's surface. (correct)
- C. The two intermediate layers of the atmosphere.

The answer to this question appeared in the following paragraph of a node:

The atmosphere consists of a relatively narrow shell of air encircling the earth that supports animal and plant life. Human activity specially affects the two layers of the atmosphere closest to the earth's surface: the troposphere which extends from the surface to about 12 miles, and the stratosphere, which extends from 12 miles up to approximately 30 miles. These portions of the atmosphere are critical in regulating our climate.

Inference Question

Ozone in the higher and lower levels of the atmosphere...

- A. Are chemically different.
- B. Differ greatly in its environmental effects. (correct)
- C. Can cause skin cancer.

To answer this question participants had to relate information contained in three different nodes:

1. Ozone is a naturally occurring gas molecule containing three atoms of oxygen. It is mainly found in two parts of the atmosphere: most (about 90%) resides in the upper atmosphere or stratosphere, where it forms the stratospheric ozone layer ; the remaining ozone, referred to as ground level ozone or tropospheric ozone, is present in the lower region of the atmosphere.
2. A range of negative environmental and human health impacts associated with ozone depletion can be identified, although their exact nature is difficult to quantify. Known effects include increased incidence of skin cancers and eye

Appendix II

disorders (e.g. cataracts), damage to the immune system and adverse effects on plant development and phytoplankton growth.

3. Observed effects of ground level ozone on human health include irritation of the eyes and air passages, damage to the mechanisms that protect the human respiratory tract and for some asthma sufferers, increased sensitivity of the airways to allergic triggers.

APPENDIX III

Salmerón, L., Kintsch, W. & Cañas, J.J. (2006). Metacomprehension and Reading Strategies in Hypertext. Manuscript submitted for publication to *Discourse Processes*.

Abstract

In the present paper we studied the role of metacomprehension skill on the selection of strategies for deciding a reading order in hypertext. Starting from prior research (Salmerón, Kintsch, & Cañas, in press), we explored three main strategies based on 1) link screen position, 2) link interest, 3) semantic relation of a link with the section just read. Models of self-regulated learning predict that readers could select strategies that lead to lower levels of comprehension (i.e. screen position and interest) if they possess low metacomprehension abilities. Results from one study revealed that low metacomprehension skilled readers based their decisions on what to read next on a default screen position or in link interest more often than their high skilled counterparts, which focused on links semantic relation. Results were qualified by readers' prior knowledge: novice pupils effectively differed on the selection pattern based on their metacomprehension skills, but topic experts did not.

Introduction

A key task in hypertext learning is the decision of what to read next (e.g. DeStefano & LeFevre, in press). Prior research has found that hypertext readers use different strategies to decide the reading order of a document, and that strategies support dissimilar levels of comprehension (Anderson-Inman & Horney, 1993; Barab, Bowdish, & Lawless, 1997; Barab, Bowdish, Young, & Owen, 1996; Barab, Fajen, Kulikowich & Young, 1996; Barab, Young & Wang, 1999; Britt, Rouet & Perfetti, 1996; Foltz, 1996; Horney & Anderson-Inman, 1994; Lawless & Kulikowich, 1996, 1998; Lawless, Mills & Brown, 2002; Niederhauser, Reynolds, Salmen & Skolmoski, 2000; Rouet, Favart, Britt & Perfetti, 1997; Salmerón, Cañas, Kintsch & Fajardo, 2005; Salmerón, Kintsch & Cañas, in press). Therefore, a critical issue for understanding and improving comprehension of hypertext readers is to identify what makes students select a particular strategy. However, contrasting to the increasing empirical evidence relating strategies and learning in hypertext, little is known about the mechanisms by which readers select a particular strategy (Alexander, Graham & Harris, 1998). In the present paper, we aim to explore the role of a potential factor affecting strategy selection in hypertext: metacomprehension skill, or the ability of assessing one's own comprehension during reading (Son & Schwartz, 2002). We shall analyze the role of metacomprehension in hypertext comprehension considering models of self-regulated learning (SRL). Next we will test hypotheses derived from these models in a study where we assess conjointly reader's metacomprehension ability and their strategies for selecting a reading order in a hypertext.

The role of metacomprehension in text comprehension has been particularly stressed by SRL models (Hacker, 2004; Pintrich, 2000; Thiede, Anderson, & Therriault, 2003). Despite their differences, SRL models share some basic assumptions about learning from text. They conceive readers as active participants in the learning process. Readers can set a goal or standard to guide their learning, monitor their comprehension during reading and regulate their reading strategies according to the match between the goal and current understanding. Therefore, for SRL models metacomprehension skill plays an important mediating role in the regulation of learning. For example, if skilled readers realize that their comprehension of a text is not being optimal according to their established goal they could engage in different remediation strategies to improve their learning (Borkowski, Carr & Pressley, 1987; Roberts & Newton, 2001).

Regarding comprehension in hypertext systems, several authors have proposed that the extra cognitive demands imposed in reading hypertext (e.g. deciding on the sequence for reading information) require hypertext readers to use metacognitive skills to a degree far greater than that necessary in regular linear text (Goldman, 1996; Rouet, 1992). Empirical support for this claim comes from intervention studies that promote the use of metacognition in hypertext tasks (Azevedo & Cromley, 2004; Azevedo, Guthrie & Seibert, 2004; Bannert, 2003, 2004; Jacobson, Maouri, Mishra & Kolar, 1996; Lin & Lehman, 1999; Schmidt & Ford, 2003; Stadler & Bromme, 2004, 2005). In a

Appendix III

standard intervention study, the experimental group either uses a hypertext that promotes the use of metacognitive processes to foster comprehension or is instructed to engage in metacognitive activities. For example, Bannert (2003) used a hypertext that at regular intervals prompted readers with questions tapping self-regulation processes, such as “Do I understand the part?”, “Am I still on time?”. Readers using this hypertext outperformed a control group (hypertext with no prompts) in a measure of inferential comprehension. In addition, some support for the role of metacomprehension in learning from hypertext comes from exploratory studies that relate individual differences in the use of metacognitive activities and learning in hypertext (Coiro & Dobler, 2006; Moss & Azevedo, 2006; Schwartz, Andersen, Hong, Howard & McGee, 2004; Stiller & Bartsch, 2005). In this type of study, metacomprehension is measured by an independent variable (e.g. questionnaire, think aloud procedure) that is correlated to comprehension measures. Schwartz et al. (2004) presented teenagers with two different hypertexts. Half learned from a networked map, and half from a hierarchical outline. Self-rated metacognitive skills predicted learning outcomes of participants only in the networked condition, suggesting that metacomprehension ability becomes more important for regulating learning as the complexity of the hypertext structures increases.

SRL models explain the effect of metacomprehension on hypertext learning by the mediating role of metacognition in the regulation of reading behaviour. This regulation and not metacognition per se would be the responsible for the learning improvement. Nevertheless, prior research has not directly evaluated the relation between metacomprehension and reading strategies in hypertext (Alexander et al., 1998). Our research explores this relation, starting with recent work by Salmerón et al. (in press). The authors explored three main strategies followed by hypertext readers: coherence (Foltz, 1996), interest (Ainley, Hidi & Berndorff, 2002) and screen default position. The coherence strategy consists of selecting text sections that are semantically related to the one just read; the interest strategy consists of selecting first those sections considered more interesting, delaying the selection of the non-interesting; whereas the screen default position consist on the selection of links based on their position on the hypertext (e.g. selecting the link that is presented on the top). In one experiment (Salmerón et al., in press; Exp 1), participants read an expository text in hypertext format and selected the reading order in their own fashion. After reading the entire text, participants were asked to identify the criterion they had used for each link selection, and subsequently grouped under a particular strategy (i.e. coherence, interest, or screen default position). Comprehension data revealed that readers with low prior knowledge on the to-be-studied topic acquired deeper levels of comprehension by following the coherence strategy, whereas readers with some prior knowledge comprehended independently of the strategy followed. Similar comprehension outcomes were obtained when readers where instructed to follow a particular strategy for deciding reading order (Salmerón et al., in press; Exp 2). Following SRL models we can predict what strategy readers will follow (i.e. coherence, interest or default screen position) based on their metacomprehension abilities. Because the effects of reading strategy depend on reader’s prior knowledge, we can make predictions for each group of knowledge (i.e. with or without prior knowledge). Given the case that readers set a high study goal, we can expect that those with low prior knowledge will follow a strategy inducing low levels of comprehension only if they have low levels of metacomprehension ability. In other words, their inability to monitor their comprehension could prevent them from using a more effective strategy. That would be the case for those novice learners deciding the reading order based on link interest or on a default screen position. Regarding topic expert readers, metacomprehension skill is likely to play minor roles in determining their strategy selection, because their comprehension is not affected by the reading strategy followed. Prior research suggests that if a reader possesses enough prior topic knowledge, metacomprehension does not critically determine comprehension in regular texts (Borkowski et al., 1987; Hasselhorn & Körkel, 1985, cited by Borkowski et al., 1987; O’Really & McNamara, 2002). In order to explore the proposed relation between metacomprehension and reading strategies we conducted a study that followed the procedure of experiment 1 of

Appendix III

Salmerón et al. (in press), adding a judgment of learning task (JOL, see description below) for objectively assessing reader's metacomprehension skill.

Experiment

Following our theoretical rationale, predictions about the relation between metacomprehension and reading strategies depend on the reader's prior topic knowledge. On the one hand, for low prior knowledge readers we expect differences on link selection between high and low metacomprehension skills: links semantically related will be selected more often by high skilled readers, whereas interesting links and those on a default screen position will be selected mostly by low skilled pupils. On the other hand, for high prior knowledge readers we expect no differences on the pattern of link selection in regards to metacomprehension ability.

Method

Participants

Eighty-two University of Colorado undergraduates participated for class credit.

Materials

Hypertext. We adapted an expository text on atmosphere pollution for its use in hypertext format. The text was 4,033 words long (including section titles), and was divided in 27 sections. Text readability was as follows: *Flesh Reading Ease* = 34.6; *Flesh-Kincaid Grade level* = 12. A hypertext was constructed in order to isolate the link selection process. The text of each section was presented one at a time on the screen, and after finishing reading it, participants could choose between only two other nodes. These two nodes were the one with the highest coherence with the previous text read, and other with the lowest coherence. Coherence between texts was computed by comparing LSA cosines for the node just read with the rest of unread nodes (the whole text of each node was used for the matrix comparison analysis, document to document test). LSA cosines provide a measure of the degree of argument overlap between texts that is assumed to reflect the level of coherence between texts (Foltz, Kintsch & Landauer, 1998). The selection of the two nodes was done automatically by choosing the one with the higher and the lower LSA cosines. The links were presented one below the other. The position of the high and low coherence link was randomized across selections. Participants were not aware of the distinction between links. Each node was presented only once and it was not possible to reread it again. For example, after reading the section entitled 'Sources of air pollutants emissions', participants could be presented with a high related section like 'Ground level ozone in metropolitan cities' (with an LSA cosine of 0.73) and with a low related section such as 'Effects of climate change in agriculture' (LSA cosine of 0.22).

Prior knowledge questions. Participants were given a pre-test of eight multiple choice questions to determine individual differences in domain knowledge prior to the reading phase. The test assessed general knowledge of the topic 'Atmosphere pollution,' rather than information specific to the text itself. Chance performance was 33%.

Inference questions. We created 10 multiple choice inference questions that required the participant to think about information located in at least two different nodes. Thus this task was intended to assess situation model comprehension. Chance performance was 33%.

Relatedness judgment task. We used a relatedness judgment task as a complement for the assessment of situation model comprehension. Participants were given a list of the 14 most important concepts in the text and were instructed to rate the degree of relatedness of pairs of concepts (the combination of all concepts resulted in 91 pairs). Participants had to respond using a scale from 1 to 6, in which 1 meant high related and 6 low related. A PhD in Atmospheric Science provided expert ratings after reading the original text. We used these scores in order to compare the participants' solution with an expert one. The final score was obtained by applying the Pathfinder algorithm

Appendix III

(Schvaneveldt, 1990) to each matrix using $r = \infty$ and $q = n-1$, and comparing the resulting Pathfinder network to the expert one.

Text-based questions. We constructed a test consisting of 22 multiple choice questions for which the question and the answer appeared in a single section and did not require the reader to infer information. Each question referred to information of a particular section. We did not construct a question for the remaining five sections because they cover a topic in a general manner and their information could be inferred from subsequent sections dealing with the topic in a specific manner. Chance performance was established at 33%.

Judgment of learning. For each section of the text, participants judged their perceived comprehension by answering to the question “How likely is it that you will be able to correctly answer a test question about the section you just read in about 25 minutes?” 0 (definitely won’t be able), 10 (10% sure I will be able), 20..., 30..., 100 (definitely will be able).” Mean ratings for all sections were subtracted from averaged percentage comprehension questions scores (including all text-based and inference questions). The absolute value of this subtraction was used as a metacomprehension skill measure (Lichtenstein, Fischhoff, & Phillips, 1982). Values could range from 0 to 100. Higher values indicated bigger difference between predicted and actual comprehension, therefore lower metacomprehension ability.

Procedure

First participants went through a pre-test of 8 multiple choice questions assessing their domain knowledge. They were then instructed on how to use the hypertext. After that, they were required to read the text without time limit. The instructions stressed that they had to read the text carefully in order to answer a series of questions about it. Special emphasis was placed on explaining that they could only choose the order in which to read the sections, but not what sections to read. The reading procedure was as follows: first participants were presented with an introductory node with an overall description of the text. After reading a section, participants had to press a button announcing that they have finished reading the text. Then they performed a judgment of learning for that section. Next a new screen appeared presenting only two links pointing to unread nodes. Here, participants had to click on a link for reading that particular section. After that, the selected text was presented on the screen with the button for announcing the end of the reading, but without any links. When only one node remained to be read, only one link corresponding to that text was presented for selection. After reading all the nodes, participants had to perform a relatedness judgment task. Then, participants had to answer 22 multiple choice text-based questions and 10 multiple choice inference questions mixed randomly. Finally, participants were asked about the criteria they had followed for selecting the links through a retrospective debriefing methodology (Poulisse, Bongaerts & Kellerman, 1987). For each selection made ($n = 25$ because the first and last texts could not be chosen), they were presented with the title of the text they read before the selection and with the two links available after reading that text (the selected link was identified). Participants had to answer for each selection why they chose that particular link from a series of reasons. That particular reasons have been identified in the pilot experiments presented above and were: “the link seemed the most interesting”, “the link seemed the easiest”, “the link seemed related to the previous text read”, “the link was the one on the top”, or “other reason” (in that case participants had to write the criteria followed). They were restricted to report one reason per choice.

Design

A quasi-experimental design was used with metacomprehension ability (low and high) and prior knowledge (low and high) as independent variables. Main dependent variable was participant’s percentage of use of different reading strategies as declared at the retrospective debriefing (coherence, interest and default screen position) for the 25 links

Appendix III

selection⁴. Two levels of metacomprehension ability were defined based on the median split of this variable. The median score was 12.94 (percentage deviation from predicted to actual comprehension scores). Participants that scored below or equal the median were classified as low metacomprehension skilled ($M = 24.09$; $SD = 9.2$), and those above as high metacomprehension skilled ($M = 6.6$; $SD = 3.58$). The two levels of prior knowledge were defined according to the median split of the answers to the eight questions about the participants' domain knowledge. The median score was 4. Participants with scores below or equal to the median were classified as low knowledge ($M = 3.07$, $SD = 0.85$) and those above as high knowledge ($M = 5.5$, $SD = 0.57$). Distribution of participants per condition can be seen in table 1.

Results

Metacomprehension analyses

All differences declared as reliable have $p < 0.05$. In order to test our hypotheses, we performed a series of ANOVAs with metacomprehension ability and prior knowledge as independent variables, and percentage of use of reading strategies as dependent variable. Because this dependent variable might violate the assumption of independence in the ANOVA, we performed a separate analysis for the percentage of use of each reading strategy (coherence, interest and default screen position). Results are summarized in Table 1. A first analysis with percentage of use of the coherence strategy revealed no significant main effect of metacomprehension ability, $F(1, 78) = 2.07$, $p < 0.2$, $MSe = 81.08$, or prior knowledge, $F < 1$. Nevertheless, the interaction between both variables resulted significant, $F(1, 78) = 4.31$. In order to test our hypotheses, we carried out planned comparisons between groups of metacomprehension ability. Supporting our expectations, novice readers with high metacomprehension ability selected more often the coherence criterion than their low skilled counterparts, $F(1, 78) = 5.49$. In addition, selection pattern of topic expert readers did not differ as a function of metacomprehension ability, $F < 1$. The second analysis with the percentage of link selection based on a screen default position also revealed no main effects of metacomprehension ability, $F < 1$, or prior knowledge, $F < 1$. Nevertheless, both variables interacted significantly, $F(1, 78) = 4.46$, $MSe = 85.4$. Planned comparisons between groups of metacomprehension ability supported our predictions: low knowledge readers with high metacomprehension ability tended to select links based on a default screen position less often than their low skilled counterparts, $F(1, 78) = 3.95$, $p = 0.05$. By contrast, high knowledge readers' pattern of link selection did not change as a function of metacomprehension skill, $F < 1$. Finally, a third ANOVA with percentage of selections based on link interest revealed a marginal main effect of metacomprehension ability, $F(1, 78) = 3.02$, $p = 0.09$, $MSe = 24.49$, but no effect of prior knowledge, $F < 1$. The effect of metacomprehension skill is qualified by a close to significant interaction, $F(1, 78) = 3.06$, $p = 0.08$. Follow up analyses revealed that novice participants with high metacomprehension ability selected links based on their interest less often than their low skilled mates, $F(1, 78) = 5.41$. As with the previous criteria analysed, topic expert reader's link selection was not affected by their metacomprehension ability, $F < 1$.

⁴ Due to the few responses on the retrospective debriefing for the 'easiest link' and 'other' criteria, these data was not included in the comprehension analyses.

Table 1

Criterion followed for link selections as a function prior knowledge and metacomprehension ability.

	Low Prior Knowledge		High Prior Knowledge	
	Low Metacomp. Skill	High Metacomp. Skill	Low Metacomp. Skill	High Metacomp. Skill
Coherence	29.5 (32.16)	57.8 (39.14)	39.04 (37.01)	33.9 (34.42)
Screen default	47.25 (40.16)	22.6 (31.26)	27.84 (35.67)	38.09 (40.78)
Interest	22.25 (20.13)	6.8 (11.02)	17.28 (23.2)	17.33 (21.52)
n	16	20	25	21

Note. Criterion data is provided in percentage. Standard deviations are provided in brackets.

Comprehension analyses

Our predictions on how metacomprehension abilities influence link selection patterns are based under the assumption that reading strategies effectively support different levels of comprehension. In order to confirm this assumption, and to replicate results of previous studies (Salmerón et al., 2005; Salmerón et al., in press), we performed a series of ANOVAs with reading strategy (see below) and prior knowledge (low and high) as independent variables, and the comprehension values as dependent variables. Participants' reading strategies were analyzed considering their responses on the retrospective debriefing method. Readers were grouped under a particular strategy if they declared having selected a majority of links following this criterion. Three main strategies assessed (i.e. coherence, screen default position and interest) accounted for 97% of the participants. Two participants declared that they had selected mainly the considered easiest links, and were excluded from the comprehension analyses. Prior research supports the reliability and validity of the use of this retrospective debriefing methodology for the analysis of readers' strategies (Poulisse et al., 1987). Nevertheless, it's recommended to validate results obtained by this method against data from the reading process (Grotjahn, 1987; Taylor & Dionne, 2000). For that reason, data from this grouping-by-declared strategy was tested against three objective variables of link selection: the percentage of times that participants selected the most coherent link, the percentage of times that they selected the link on the top, and the mean time participants spent selecting the reading order. Results are summarized in Table 2. An ANOVA with reading strategy (first-mentioned, interest and coherence) on the percentage of coherent link selection revealed a significant difference, $F(2, 75) = 48.95$, $MSe = 135.4$. Participants of the coherence group selected the coherent link more often ($Mean\ selection\ percentage = 79.57$, $SD = 9.76$) than those of the interest group ($M = 57.63$, $SD = 11.91$), $F(1, 75) = 45.2$, and both groups also selected the coherent link more often than those on the first-mentioned ($M = 47.85$, $SD = 12.82$), $F(1, 75) = 94.45$ and $F(1, 75) = 9.53$, respectively. A second ANOVA with percentage of selection of the link on the top resulted in significant differences, $F(2, 75) = 59.19$, $MSe = 182.5$. Participants on the first-mentioned group selected the link on the top more often ($M = 90.52$, $SD = 9.36$), than those on the interest ($M = 61.93$, $SD = 18.64$), $F(1, 75) = 60.47$, and both groups chose the upper link more often than participants on the coherence group ($M = 51$, $SD = 10.16$), $F(1, 75) = 108.72$ and $F(1, 75) = 8.31$, respectively. Finally, a third ANOVA with mean time on the link decision process revealed significant differences, $F(2, 75) = 12.68$, $MSe = 1.71$. Readers selected links on the first-mentioned group faster ($M = 3.48$ seconds, $SD = 1.32$), than those on the interest ($M = 4.47$, $SD = 1.45$) and coherence groups ($M = 5.32$, $SD = 1.09$), $F(1, 75) = 7.68$ and $F(1, 75) = 25.21$, respectively. Readers that mainly followed the interesting links were also faster

Appendix III

than those that mainly selected the coherent link, $F(1, 75) = 5.44$. The three ANOVAs supported the strategy grouping by the retrospective debriefing method. Participants following the coherence strategy differed from those mainly selecting the interesting links in that the former selected the high coherent link more often, and spend more time deciding the reading order. Compared to those strategies, participants following a screen default criterion selected more often the first-mentioned link and spent less time deciding the reading order to follow.

As in previous works (Salmerón et al., 2005; Salmerón, et al., in press), we expected that low knowledge readers following the coherence strategy will learn more, as measured by a judgment relatedness task and inference questions, which tap comprehension at the situation model level (i.e. a representation of what the text is about that integrates the information with readers' prior knowledge). In addition, no effect of strategy is expected for high knowledge readers. Indeed, for the Pathfinder similarity values, an ANOVA reported main effects of strategy, $F(2, 74) = 5.06$, $MSe = 0.01$, and prior knowledge, $F(1, 74) = 32.27$, $MSe = 0.01$. Participants following the coherence strategy scored higher than the other participants, as did high knowledge readers compared to low knowledge participants. Both effects are qualified by a close to significant interaction between variables, $F(2, 74) = 2.54$, $MSe = 0.01$, $p = 0.08$. For low knowledge participants, planned comparisons showed that readers following the coherence strategy scored higher than those selecting the first-mentioned link, $F(1, 74) = 6.62$, and than those focusing on the interesting links, $F(1, 74) = 12.68$. No difference was found between participants on the first-mentioned and the interest strategy, $F(1, 74) = 1.16$, $p < 0.3$. High knowledge participants scored similarly across strategies (for all paired comparisons $F_s < 1$). In addition, comparisons across prior knowledge groups revealed significant differences for the first-mentioned and interest strategies, but not for the coherence strategy, $F(1, 74) = 2.54$, $p < 0.15$. Second, for the inference questions scores, an ANOVA yielded only a significant main effect of prior knowledge, $F(1, 74) = 7.43$, $MSe = 191.1$. High knowledge readers seemed to outperform their low knowledge counterparts. Although the interaction between variables was not significant, $F(2, 74) = 1.59$, $MSe = 191.1$, $p = 0.21$, we relied on prior results supporting this effect (Salmerón et al., in press, Exp 1), in order to perform follow-up analyses (Rosenthal & Rosnow, 1985). Indeed, results revealed a similar pattern than those found for the Pathfinder similarity values. For low knowledge readers, those following the coherence strategy seemed to outperform those mainly selecting the first-mentioned link, $F(1, 74) = 3.61$, $p = 0.06$, and those that chose the interest strategy, $F(1, 74) = 3.59$, $p = 0.06$. No differences were found between participants of the first-mentioned and the interest strategy groups, $F < 1$. Similarly, no differences were observed between strategies for high knowledge readers (all comparisons reported $F_s < 1$, except First-mentioned vs. Interest, $F(1, 74) = 2.69$, $p < 0.15$). Regarding the prior knowledge effect, it reached significance only for the interest group, $F(1, 74) = 8.26$. Neither first-mentioned link, $F(1, 74) = 2.3$, $p < 0.15$, nor coherence groups, $F < 1$, differed by prior knowledge.

For the text-based questions tapping the textbase representation (i.e a hierarchical propositional representation of the information within the text), we expected no differences between strategies for deciding reading order (Salmerón et al., 2005; Salmerón et al., in press). However, an ANOVA revealed a main effect of strategy, $F(1, 74) = 3.51$, $MSe = 255.7$. A Fisher's *LSD* post-hoc test showed that participants in the coherence strategy scored higher than those on the first-mentioned link group ($p < 0.05$) and moderately higher than those on the interest strategy ($p = 0.06$). No differences were observed between the first-mentioned and the interest strategy groups. Finally, neither the main effect of prior knowledge nor the interaction resulted significant.

Table 2

Mean comprehension and metacomprehension scores as a function of prior knowledge and strategy.

	Low Prior Knowledge			High Prior Knowledge		
	First-mentioned	Interest	Coherence	First-mentioned	Interest	Coherence
Pathfinder	0.22 (0.09)	0.19 (0.05)	0.29 (0.07)	0.31 (0.08)	0.33 (0.06)	0.34 (0.07)
Inference	36.27 (15.22)	35.66 (9.42)	46.86 (11.9)	44.33 (17.26)	51.88 (14.05)	48.8 (9.72)
Text-based	53.64 (20.81)	55.55 (14.79)	66.42 (13.27)	61.22 (15.55)	61.44 (16.95)	70.5 (13.16)
n	11	9	14	18	18	10

Note. Inference and text-based scores are reported in percentage of correct answers. Ratings are reported in the Pathfinder C similarity value, which scores range from 0 to 1. Standard deviations are provided in brackets.

Discussion

Results from this experiment address important issues on both metacomprehension and comprehension in hypertext. We will first focus on the role of metacomprehension skill on link selection, and then move to the effect of reading strategies on hypertext comprehension.

The role of metacomprehension skill on link selection

Data from our study support the relation between metacomprehension ability and strategy selection predicted by SRL models of learning (Hacker, 2004; Pintrich, 2000; Thiede et al., 2003). These models propose that after having set a study goal, readers monitor their learning during reading in order to adjust their strategies to actual comprehension. Results from our study reveal that when readers do not possess prior knowledge of the to be learned topic, their selection of strategies for deciding reading order is mediated by their metacomprehension skill. Readers with low metacomprehension skill select more often strategies that lead to non-optimal comprehension, such the selection of links based on a screen default position or on the link interest. Results suggest that their poor comprehension monitoring during reading could have prevented them from using a more optimal strategy for learning (Borkowski et al., 1987; Roberts & Newton, 2001). High skilled readers, by contrast, tended to stick to optimal strategies, such the selection of reading order based on link semantic relation to the just read section. Furthermore, data reveals that high knowledge readers choose criteria for deciding reading order independently of their metacomprehension skill (Borkowski, et al., 1987; Hasselhorn & Körkel, 1985, cited by Borkowski et al., 1987; O'Really & McNamara, 2002). The activation of their prior knowledge allows them to learn at the same level with any reading strategy; for that reason, metacomprehension is not critical in order to regulate their reading behaviour.

Effect of reading strategies on hypertext comprehension

Conclusions about the relation between metacomprehension skill and link selection are based on the assumption that reading strategies lead to different learning outcomes. Indeed, comprehension data from our study corroborates this assumption and replicates existing results for situation model measures (Salmerón et al., 2005; Salmerón et al., in press), and provides new insights on the effect of reading strategies on textbase level comprehension.

Appendix III

Regarding situation model comprehension (measured by Pathfinder and inference scores), the data reveal a significant effect of reading strategies for novice readers. The coherence strategy supports better learning, probably because this strategy prevents readers from coherence breaks related to reading order. By contrast, for topic experts the three strategies analyzed benefit comprehension equally. This result suggests that for knowledgeable readers those strategies support an active processing of the hypertext, which helps them build a coherent representation of the text. In the case of the first-mentioned and interest strategies, this activation could come from the coherence breaks of the reading order (McNamara & Kintsch, 1996; McNamara, Kintsch, Songer, & Kintsch, 1996; Schnotz, 1982). By contrast, for the coherence strategy this activation could be due to the semantic processing necessary in order to select links leading to related sections (for a detailed discussion of this and other effects on hypertext comprehension see Salmerón et al., in press). Regarding text-based questions, results show that participants following the coherence strategy outperform those mainly selecting the interesting and first-mentioned links, contrasting to the null effects found previously (Salmerón et al., in press). Interestingly, this conflicting result can help us to understand how reading strategies affect construction of textbase representation, and can be explained due to the differences in the procedure used in both studies. In Salmerón et al. (in press) experiments, participants select and are presented with the subsequent section immediately after having finished reading a particular section. However, in the current study participants perform a JOL task between the end of section and the selection and presentation of subsequent sections. On average, each JOL take participants 5.13 seconds ($SD = 1.1$). The introduction of this task may have interfered with the construction of a coherent textbase representation, for which readers must relate relevant propositions in the current section to those on the next one (e.g. Budd, Whitney & Turley, 1995). Similarly, prior works have found that interruptions during reading are likely to decrease readers' comprehension (Glanzer, Dorfman, & Kaplan, 1981; Glanzer, Fischer, & Dorfman, 1984; Lorch, 1993). In the current experiment, participants on the first-mentioned and interest groups are affected by the interruption more severely than those on the coherence group, probably because after the JOL interruption they must reinstate propositions from the previous section that are mostly unrelated to the subsequent section (Levy et al., 1995).

Suggestions for future research

In the current work we used a simplified hypertext in order to clearly identify the role of metacomprehension skill on the selection of a reading order, a key task in hypertext comprehension (DeStefano & LeFevre, in press). Needless to say, educational hypertexts are far more complex systems with several other features (e.g. graphical overviews, embedded links ...) and support other tasks (e.g. search for information) that can also influence reader's learning. Therefore, future research might address how metacomprehension affects readers' use of other hypertext features rather than the selection of reading order. For example, Shapiro & Niederhauser (2004) have suggested that monitoring skills could be related to the process of deciding what sections to read, an important task that can affect comprehension (Salmerón et al., 2005). In addition, future research might consider SRL as a starting point for further understanding the role of metacomprehension in hypertext comprehension. Although results from the present study reveal that novice high skilled readers base their reading order selection mainly on the coherence criterion, they still select other non-optimal strategies 42.2 % of the times. SRL models suggest at least two factors that could induce readers with high metacomprehension skill to choose a non-optimal but less demanding strategy: the establishment of a low study goal (Mazzoni & Cornoldi, 1993; Thiede & Dunlosky, 1999; Pelegrina, Bajo & Justicia, 1999; Zumbach & Reimann, 2002) or a lack of motivation to accomplish a particular goal (Moss & Azevedo, 2006; Rheinberg, Vollmeyer & Rollett, 2000). Regarding the first possibility, differences on the study goal can lead skilled readers to follow different strategies. Thiede & Dunlosky (1999, Exp 1) exemplify this possibility in a word-pairs study. Participants read thirty pairs of words and afterwards were instructed either to memorize them in order to be able to recall at least twenty-four pairs (high goal), or to just to learn six pairs (low goal). Participants on the high goal condition selected a high

Appendix III

demanding strategy: they chose for restudy mainly those pairs rated as more difficult to memorize. By contrast, participants on the low goal condition selected a low demanding strategy: they restudied mainly pairs rated as less difficult to memorize. A second factor that could explain the selection of non-optimal strategies by high skilled readers is a lack of motivation to accomplish a goal (Moss & Azevedo, 2006; Rheinberg et al., 2000). Readers can decide to choose a low demanding strategy as the selection of first-mentioned links even when they realize that their learning is not optimal, if they lack the necessary motivation to accomplish the study goal. Further research will be required to fully understand these effects.

References

- Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 545-561.
- Alexander, P. A., Graham, S., & Harris, K. R. (1998). A perspective on strategy research: progress and prospects. *Educational Psychology Review, 10*, 129-154.
- Anderson-Inman, L., & Horney, M. A. (1994). The electrotext project: Hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia, 3*, 71-91.
- Azevedo, R. (2002). Beyond intelligent tutoring systems: Computers as MetaCognitive tools to enhance learning? *Instructional Science, 30*, 31-45.
- Azevedo, R. & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology, 96*, 523-535.
- Azevedo, R., Guthrie, J. T., Seibert, D. (2004). The role of self-regulated learning in fostering students' conceptual understanding of complex systems with hypermedia. *Journal of Educational Computing Research, 30*, 87-111.
- Bannert, M. (2003). Effekte metakognitiver lernhilfen auf den wissenserwerb in vernetzten lernumgebungen [Effects of metacognitive help on knowledge acquisition in web-based learning environments]. *Zeitschrift für Pädagogische Psychologie, 17*, 1, 13-25.
- Bannert, M. (2004). Designing metacognitive support for hypermedia learning. In H. Niegemann, D. Leutner & R. Brünken (Eds.). *Instructional Design for Multimedia-Learning* (pp.19-30). Münster, Germany: Waxmann.
- Barab, S. A., Bowdish, B. E., & Lawless, K. A. (1997). Hypermedia navigation: profiles of hypermedia users. *Educational Technology Research and Development, 45*, 23-42.
- Barab, S. A., Bowdish, B. E., Young, M. F., & Owen, S. V. (1996). Understanding kiosk navigation: using log files to capture hypermedia searches. *Instructional Science, 24*, 377-395.
- Barab, S. A., Fajen, B. R., Kulikowich, J. M. & Young, M. F. (1996). Assessing hypertext navigation through Pathfinder: prospects and limitations. *Journal of Educational Computing Research, 15*, 185-205.
- Barab, S. A., Young, M. F., & Wang, J. (1999). The effects of navigational and generative activities in hypertext learning on problem solving and comprehension. *International Journal of Instructional Media, 26*, 283-309.
- Borkowski, J., Carr, M., & Pressely, M. (1987). "Spontaneous" strategy use: perspectives from metacognitive theory. *Intelligence, 11*, 61-75.
- Britt, M.A., Rouet, J.-F., & Perfetti, C.A. (1996). Using hypertext to study and reason about historical evidence. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 43-72). Mahwah, NJ: Lawrence Erlbaum Associates.
- Budd, D., Whitney, P., & Turley, K. J. (1995). Individual differences in working memory strategies for reading expository text. *Memory & Cognition, 23*, 735-748.

Appendix III

Coiro, J., & Dobler, E. (in press). Reading comprehension on the Internet: Exploring the online comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*.

Glanzer, M., Dorfman, D., & Kaplan, B. (1981). Short-term storage in the processing of text. *Journal of Verbal Learning and Verbal Behavior*, 20, 656–670.

Glanzer, M., Fischer, B., & Dorfman, D. (1984). Short-term storage in reading. *Journal of Verbal Learning and Verbal Behavior*, 23, 467–486.

DeStefano, D. & LeFevre, J-A. (in press). Cognitive load in hypertext reading: A review. *Computers and Human Behavior*.

Dunlosky, J., & Hertzog, C. (1998). Training programs to improve learning in later adulthood: Helping older adults educate themselves. In D. J. Hacker (Ed.), *Metacognition in educational theory and practice* (pp. 249-275). Mahwah, NJ: Erlbaum.

Foltz, P. W. (1996). Comprehension, coherence, and strategies in hypertext and linear text. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp. 109-136). Mahwah, NJ: Lawrence Erlbaum Associates.

Foltz, P. W., Kintsch, W., & Landauer, T. K. (1998). The measurement of textual coherence with Latent Semantic Analysis. *Discourse Processes*, 25, 285-307.

Glanzer, M., Dorfman, D., & Kaplan, B. (1981). Short-term storage in the processing of text. *Journal of Verbal Learning and Verbal Behavior*, 20, 656–670.

Glanzer, M., Fischer, B., & Dorfman, D. (1984). Short-term storage in reading. *Journal of Verbal Learning and Verbal Behavior*, 23, 467–486.

Goldman, S. R. (1996). Reading, writing, and learning in hypermedia environments. In H. Van Oostendorp and S. de Mul (Eds.), *Cognitive aspects of electronic text processing* (pp. 7-42). Norwood, N.J.: Ablex.

Grotjahn, R. (1987). On the methodological basis of introspective methods. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 54-81). Philadelphia: Multilingual Matters, Ltd.

Jacobson, M. J., Maouri, C., Mishra, P., & Kolar, C. (1996). Learning with hypertext learning environments: theory, design, and research. *Journal of Educational Multimedia and Hypermedia*, 5, 239 – 281.

Jonassen, D., & Wang, S. (1993). Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction*, 20, 1–8.

Hacker, D. J. (2004). Self-regulated comprehension during normal reading. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice*. Mahwah, NJ: Erlbaum.

Horney, M. A., & Anderson-Inman, L. (1994). The electrotext project: hypertext reading patterns of middle school students. *Journal of Educational Multimedia and Hypermedia*, 3, 71-91.

Lawless, K. A., & Kulikowich, J. M. (1996). Understanding hypertext navigation through cluster analysis. *Journal of Educational Computing Research*, 14, 385-399.

Lawless, K. A., & Kulikowich, J. M. (1998). Domain knowledge, interest, and hypertext navigation: a study of individual differences. *Journal of Educational Multimedia and Hypermedia*, 7, 51-70.

Lawless, K. A., Mills, R., & Brown, S. W. (2002). Children's hypermedia navigational strategies. *Journal of Research on Computing in Education*, 34, 274-284.

Levy, B. A., Campsall, J., Browne, J., Cooper, D., Waterhouse, C., & Wilson, C. (1995). Reading fluency: episodic integration across texts. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 1169-1185.

Appendix III

Lichtenstein, S., Fischhoff, B., & Phillips, L. D. (1982). Calibration of probabilities: The state of the art to 1980. In D. Kahneman, P. Slovic, & A. Tversky (Eds.), *Judgment under uncertainty: Heuristics and biases*. Cambridge, UK: Cambridge Univ. Press.

Lin, X. & Lehman, J. D. (1999). Supporting learning of variable control in a computer-based biology environment: effects of prompting college students to reflect on their own thinking. *Journal of Research in Science Teaching*, 36, 837–858.

Lorch, R. F. (1993). Integration of topic and subordinate information during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 1071–1081.

Mazzoni, G. & Cornoldi, C. (1993). Strategies in study time allocation: Why is study time sometimes not effective? *Journal of Experimental Psychology: General*, 122, 47-60.

McNamara, D. S., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interaction of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1-42.

McNamara, D. S., & Kintsch, W. (1996). Learning from text: effect of prior knowledge and text coherence. *Discourse Processes*, 22, 247-288.

Moos, D. C. & Azevedo, R. (2006). The role of goal structure in undergraduates' use of self-regulatory processes in two hypermedia learning tasks. *Journal of Educational Multimedia and Hypermedia*, 15, 49-86

Niederhauser, D. S., Reynolds, R. E., Salmen, D. J., & Skolmoski, P. (2000). The influence of cognitive load on learning from hypertext. *Journal of Educational Computing Research*, 23, 237-255.

O'Reilly, T., & McNamara, D. S. (2002). What's a science student to do? In W. D. Gray & C. D. Schunn (Eds.), *Proceedings of the Twenty-fourth Annual Meeting of the Cognitive Science Society*, 726-731. Mahwah, NJ: Erlbaum.

Pelegriana, S., Bajo, M. T., & Justicia, F. (1999). Allocation of time in self-paced memory tasks: The role of practice, instructions, and individual differences in optimizing performance. *Learning and Individual Differences*, 11, 401-429.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds). *Handbook of Self-Regulation* (pp. 451-502). San Diego: Academic Press.

Poulisse, N., Bongaerts, T., & Kellerman, E. (1987). The use of retrospective verbal reports in the analysis of compensatory strategies. In C. Faerch & G. Kasper (Eds.), *Introspection in second language research* (pp. 213-299). Philadelphia: Multilingual Matters, Ltd.

Pressley, M., Symons, S., McDaniel, M. A., Snyder, B. L., & Turnure, J. E. (1988). Elaborative interrogation facilitates acquisition of confusing facts. *Journal of Educational Psychology*, 80, 268-278.

Rheinberg, F., Vollmeyer, R. & Rollett, W. (2000). Motivation and action in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds). *Handbook of Self-Regulation* (pp. 503-529). San Diego: Academic Press.

Roberts, M. J., & Newton, E. J. (2001). Understanding strategy selection. *International Journal of Human-Computer Studies*, 54, 137-154.

Rosenthal, R. & Rosnow, R. L. (1985). *Contrast analysis. Focused comparisons in the analysis of variance*. New York: Cambridge University Press.

Rouet, J.F. (1992). Cognitive processing of hyperdocuments: When does nonlinearity help? *Proceedings of the ACM Conference on Hypertext*, 131–140.

Rouet, J.-L., Favart, M., Britt, M. A. & Perfetti, C. A. (1997). Studying and using multiple documents in history: Effects of discipline expertise. *Cognition & Instruction*, 15, 85-106.

Appendix III

Salmerón, L., Cañas, J.J., Kintsch, W. & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes*, 40, 171-191.

Salmerón, L., Kintsch, W. & Cañas, J. J. (in press). Reading strategies and prior knowledge in learning with hypertext. *Memory & Cognition*.

Schnotz, W. (1982). How do different readers learn with different text organizations? In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 87-97). Amsterdam: North-Holland.

Schvaneveldt, R. (Ed.) (1990). *Pathfinder associative networks: studies in knowledge organization*. Norwood, NJ: Ablex.

Schwartz, N. H., Andersen, C., Hong, N., Howard, B. & Mcgee, S. (2004). The influence of metacognitive skills on learners' memory of information in a hypermedia environment. *Journal of Educational Computing Research*, 31, 77-93.

Shapiro, A.M., & Niederhauser, D. (2004). Learning from hypertext: research issues and findings. In D.H. Jonassen (Ed), *Handbook of Research on Educational Communications and Technology*, 2nd Ed. (pp 605-620). Mahwah, NJ: Lawrence Erlbaum Associates.

Stadtler, M. & Bromme (2005). Dealing with multiple documents on the WWW: The role of metacognition in the formation of documents models. In B. G. Bara, L. Barsalou, & M. Bucciarelliof (Eds.). *Proceedings of the 27th Annual Conference of the Cognitive Science Society*, (pp. 2068-2073) Mahwah, NJ: Erlbaum.

Stadtler, M., & Bromme, R. (2004). Laypersons searching the WWW for medical information: The role of metacognition. In K. Forbus, D. Gentner, & T. Reiger (Eds.), *Proceedings of the 26th Annual Conference of the Cognitive Science Society* (p. 1638). Mahwah, NJ: Erlbaum.

Stiller, K., & Bartsch, M. (2005). Computerbasiertes lernen mit linearem vs. bildbezogenem textabruf und vorwissen [Computer based learning with linear vs. picture oriented access to text and prior knowledge]. *Psychologie in Erziehung und Unterricht*, 52, 210-222.

Son, L. K. & Schwartz, B. L. (2002). The relation between metacognitive monitoring and control. In T. J. Perfect & B. S. Schwartz (Eds.), *Applied metacognition* (pp. 15-38). Cambridge, UK: Cambridge University Press.

Taylor, K. L., & Dionne, J. P. (2000). Accessing problem-solving strategy knowledge: the complementary use of concurrent verbal protocols and retrospective debriefing. *Journal of Educational Psychology*, 92, 413-425.

Thiede, K. W., Anderson, M. C. M., & Therriault, D. (2003). Accuracy of metacognitive monitoring affects learning of texts. *Journal of Educational Psychology*, 95, 66-73.

Thiede, K. W., & Dunlosky, J. (1999). Toward a general model of self-regulated study: an analysis of selection of items for study and self-paced study time. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25, 1024-1037.

Zumbach, J. & Reimann, P. (2002). Enhancing learning from hypertext by inducing a goal orientation: Comparing different approaches. *Instructional Science*, 30, 243-267.

APPENDIX IV

Salmerón, L., Baccino, T. & Cañas, J.J. (2006). Learning with hypertext overviews: evidence from eye movement patterns. *Manuscript in preparation.*

Abstract

Graphical overviews are text devices intended to foster learning by conveying in a schematic way the text structure. Despite its importance in current learning systems such as hypertext, psychological research does not agree on how overviews affect hypertext reader's comprehension. Indeed, little is known about how hypertext readers process graphical overviews, and how this processing influences comprehension. In the present paper we report an experiment using the eye-movements technique in order to explore the role of prior knowledge and coherence on the visual processing of graphic overviews. Results reveal that both variables influence visual processing of graphical overviews and that this processing systematically altered what was learned from the text.

Appendix IV

Current psychological models describe text comprehension as the process of acquiring a coherent mental representation of the text. During this process, readers deal with different levels of this representation: a macrolevel of text general organization, and a microlevel of subordinate text information (Kintsch, 1998). In traditional linear texts, authors use a specific presentation order to signal general text organization to readers (Britton, 1994; Hofmann, 1989). For instance, well written texts can be expected to present main ideas at the beginning of sections, anticipating elaboration of these ideas (Garner et al., 1986). However, in non-linear systems like hypertext reading order of text sections is not preset by authors, so readers have to rely on other text features to form a coherent representation of the text (Goldman, 1996). Different hypertext devices assist readers in this task, like graphical overviews, a text device that conveys text structure by depicting text sections and their relations. However, current psychological research does not agree on how overviews affect hypertext reader's comprehension (DeStefano & LeFevre, in press; Dillon & Gabbard, 1998; Salmerón, Cañas, Kintsch & Fajardo, 2005; Shapiro & Niederhauser, 2004; Unz & Hesse, 1999). Indeed, there exist evidence for positive, null and negative effects of overviews containing structural information on the content compared to an unstructured one (e.g. list of contents, linear version). Most research on the field have relied on off-line measures of comprehension (i.e. questionnaires taken at the end of the study session) in order to infer the cognitive processes involved on the learning task (Rouet & Passerault, 1999). This approach limits our understanding of the processes readers engage during learning, information that could be useful to clarify the role of overviews on hypertext comprehension. In this paper we will use on-line processing measures (i.e. readers' eye-movements during overview processing) to explore the strategies that hypertext readers use in order to process information in overviews, and how different processing strategies influence text comprehension (cf. Hyönä, Lorch & Kaakinen, 2002). We shall first review relevant literature on eye-movements in reading to draw hypotheses on the processes involved on visual processing of graphical overviews. Next, we describe an experiment aimed to test these hypotheses using eye-movements methodology.

Factors affecting overview processing

A main objective of the present paper is to explore the strategies readers engage in to process hypertext overviews. Unfortunately, few studies have directly addressed this issue (Naumann, Waniek & Krems, 2001; Waniek, Brunstein, Naumann & Krems, 2003). Therefore, we will rely on prior research on eye-movements and reading in order to draw preliminary hypotheses about hypertext overview processing. Concretely, we will explore the role of two main factors involved in text comprehension that could also be involved in processing of hypertext overviews: reader's prior knowledge and text coherence (Kintsch, 1998). A wealth of evidence supports the fact that readers with some prior knowledge on text topic can activate it in order to help building a coherent text representation or whenever a text difficulty arises (e.g. McNamara & Kinsch, 1996; Voss & Silfies, 1996). In addition, some studies have assessed how prior knowledge might influence visual processing strategies in reading linear text (Kaakinen, Hyönä & Keenan, 2003; Soederberg Miller & Stine-Morrow, 1998; Wiley & Rayner, 2000). Readers provided with background knowledge information perform fewer and shorter regressions than those without background information (Kaakinen et al., 2003; Wiley & Rayner, 2000). Regressions are associated with a failure to incorporate text propositions into a coherent mental representation (Rayner, 1998), a process that is facilitated by prior knowledge. In relation to the present study, readers with prior topic information can make use of their existing knowledge to generate a representation of the (hyper)text structure. Nevertheless, in order to do that, readers without prior knowledge must rely on different (hyper)text features, such graphical overviews (Goldman, 1996). From these results we can hypothesize that low knowledge readers would perform more and longer regressions to information in overviews than their high knowledge mates while learning in hypertext.

A second factor which role in overview processing will be explored is text coherence that refers to the extent to which a reader is able to understand the relations between ideas in a text. Coherence properties come from those text

Appendix IV

features that help readers to understand and link ideas in the text (Lowerse, 2001). Prior research has found that text coherence systematically affect visual processing of linear text (Rink, Gámez, Díaz & de Vega, 2003; Vauras, Hyönä & Niemi, 1992). Rink et al. (2003) presented readers a set of seven sentence texts. Information in the second sentence presented a temporal inconsistency with information in the sixth. Participants performed longer regressions to the second sentence starting from the sixth. In relation to our work, reading order in hypertext has coherence properties that could influence its comprehension easiness (Charney, 1994; Fritz, 1999). Indeed, novice readers that mainly ‘jump’ between semantically related sections understand the text better than if those that mostly ‘navigate’ between unrelated parts (Salmerón et al., 2005). Therefore, we can expect that readers of an incoherently ordered hypertext would reprocess overviews more often in order to overcome comprehension difficulties derived from coherence breaks on the text.

Overview processing strategies and learning

In the previous section we discussed two factors that might influence the strategies readers use in order to process hypertext overviews. In addition, a second objective of this paper is to explore how these processing strategies might influence learning. Prior knowledge and coherence are well known factors facilitating comprehension. Interestingly, when both factors are present in the same reading situation, an interaction might arise. Low knowledge readers learn better from a highly coherent text than from an incoherent one, whereas readers with high domain knowledge actually learn more from an incoherent text than from a highly coherent one (McNamara, E. Kintsch, Songer & W. Kintsch, 1996; McNamara & Kintsch, 1996). The explanation for this effect is that unknowledgeable readers cannot fill in gaps in the incoherent text without explicit guidance about relationships among information items; on the other hand, knowledgeable readers who are overguided will not actively use their own prior knowledge to form a complete representation of the text. In other words, prior knowledge is only beneficial when readers activate it in order to form a coherent text representation (E. Kintsch & W. Kintsch, 1995; Gilabert, Martínez, & Vidal-Abarca, 2005). Knowledge activation can be induced by semantic features in the text (i.e. coherence breaks on the text) or surface form markers such indentation (Schmid & Baccino, 2002), but also be prevented by it (i.e. an easy text). Similarly, structured hypertext overviews could prevent knowledgeable readers from using their existing knowledge (Shapiro, 1998). This suggest that high knowledge readers devoting more processing time to overviews would not activate their existing knowledge, and thus might learn less than those ignoring overviews and focusing on their existing knowledge to form a coherent representation of the text organization. Nevertheless, overviews could also facilitate comprehension for those readers which do not possess prior topic knowledge, by helping them to build a coherent representation of text macrostructure (Lorch & Lorch, 1996). Therefore, low knowledge readers processing more actively graphic overviews might actually learn more than those not processing them. In addition, these effects of overview processing strategies for high and low prior knowledge readers could be modulated by text coherence. Prior studies suggest that a text support feature such as graphical overviews might foster learning only when text imposes extra difficulties for comprehension, for example, when learners read a text which paragraphs are presented in a low coherent order (Mayer, 1978, 1979). Otherwise, overviews would not provide additional information on text structure, thus could be unhelpful for the construction of a coherent representation of the text.

The following experiment was designed in order to test these hypotheses (see below). Participants read several expository texts that varied on their familiarity and order coherence and included graphical overviews, while their eye-movements were recorded.

Experiment

In the current experiment we shall explore two sets of hypotheses concerning reader’s processing strategies of graphical overviews, and its relation with learning from text. On the one hand, overview processing hypotheses state

Appendix IV

that: Readers visually process graphical overviews for a longer time when they are not familiar with text topic (compared to those that are familiar with the topic), and when they read a low coherently ordered text (compared to those reading a high coherently ordered text). On the other hand, hypotheses relating processing strategies and learning establish that: When reading a low coherently ordered text, a positive relation holds between amount of time of visual processing of graphical overviews and text comprehension for unfamiliar texts, whereas a negative relation exists for familiar texts. No such effect of topic familiarity is expected for high coherent texts.

Method

Participants

Thirty-two third-year psychology students from the University of Nice Sophia-Antipolis participated in the study for class credit. All participants were native speakers of French with normal or corrected-to-normal visual acuity. Data of 4 participants were excluded from analyses because of incomplete or inaccurate recordings. Hence, reported analyses are based on data of 28 participants.

Apparatus

Eye movements were recorded by a Tobii 1750 eye-tracking system. Data was registered binocularly at a rate of 50 Hz. Participants were seated approximately 60 cm from the presentation screen. Their head movements were restricted by means of a chinrest. Calibration of eye tracker was performed at two moments: before reading a practice text, and before reading the 11th text.

Materials

Texts. Twenty expository texts in French were constructed. Half of these texts were on topics highly related to participants' field of expertise (i.e. psychological topics, such 'Forgetting', 'Learning'), and the other half were texts on other disciplines (e.g. 'Italian Renaissance', 'Eclipses'). Experimental texts were relatively short ($M = 234$ words, $SD = 17$, for the psychology texts; $M = 259$ words, $SD = 18$, for the other disciplines texts) and followed a hierarchical organization consisting on five sections (see Appendix for a sample text). For each text there was an introductory passage, two sections on two main topic issues, and other two sections giving examples of each two main issues. In each section, no explicit reference to other sections was made. For each text there was a coherently ordered version, that was presented as follows: introduction, topic issue 1, continuation / example of topic issue 1, topic issue 2, continuation / example of topic issue 2; and an incoherently ordered version, that read as follows: continuation / example of topic issue 2, continuation / example of topic issue 1, topic issue 2, topic issue 1, introduction. In addition, all texts were displayed with a unique graphic overview that depicted the hierarchical structure of the text (see example in Figure 1).

Comprehension questions. There were two open ended questions for each text: one that referred to a single statement presented in one section (text-based question) and another which answer required to link at least two ideas presented in two or three separate sections (inferential question) (see Appendix for sample questions).

Procedure

Before the actual experiment, the eye tracker was calibrated for each participant. Students were then instructed to read each text carefully enough to answer some comprehension questions after reading all texts. They first read a practice text and were told that an overview depicting the text structure would be always displayed on the upper part of the screen. Afterwards, they went through the 20 experimental texts, with a small pause before the 11th text that was used to perform a second calibration of the eye tracker. The overview was available during all reading on the upper part of the screen, and each text was presented one section at a time on the bottom part of the screen, with the participant indicating when he / she wanted to move to the next section by pressing a key. The preceding section disappeared when new section was presented (Figure 1). Before the presentation of each text section, a fixation cross pointing to the first word of the text was displayed on a blank screen for 500 ms. Although presentation of text was self-paced, the order in

Appendix IV

which sections appeared was fixed by the experimenter, rather than chosen by the participant, as would normally be the case for hypertext. This was done in order to avoid noise in comprehension measures introduced by participants following heterogeneous reading orders (Salmerón et al., 2005). Comprehension questions were presented after all readings were finished, in the same individually randomized order in which texts were read. Finally, participants rated their prior knowledge on the topic texts prior to the experiment in a scale between 0 (no prior knowledge) to 10 (high prior knowledge). The complete experimental session did not last more than one hour.

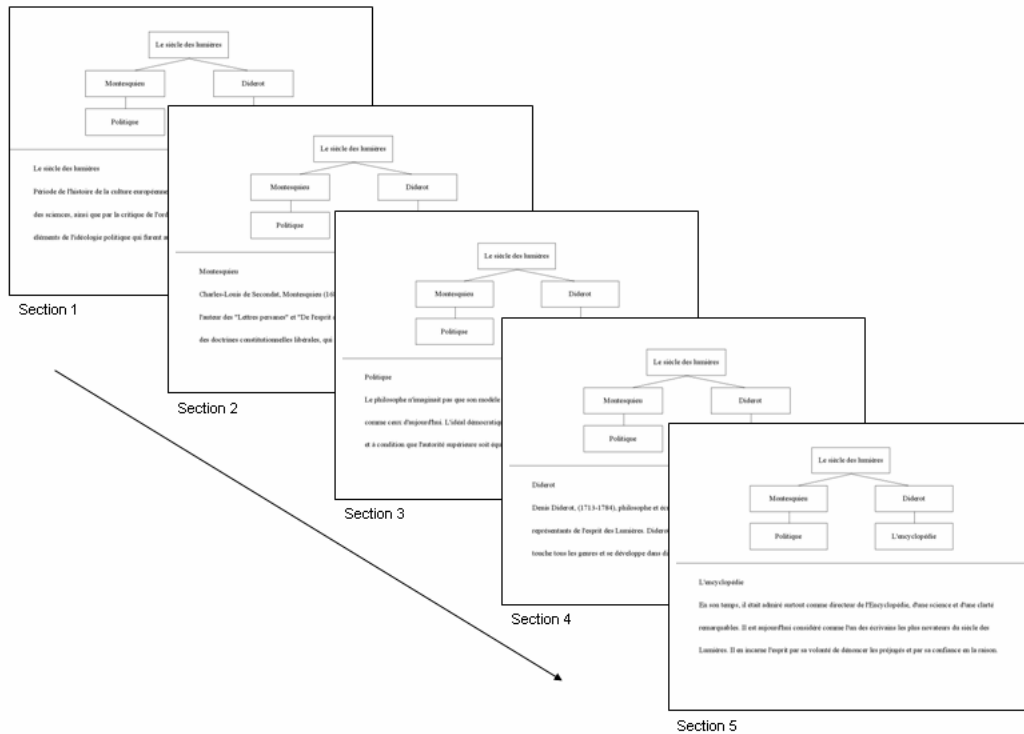


Figure 1: Reading sequence of a coherent text.

Design

The experiment followed a $2 \times 2 \times 2 \times 5$ within-subjects design with Familiarity (low and high), Text coherence (low and high), Zone (overview and text) and Section order (first to last section) as factors. Section order referred to the order in which each of the five text sections were displayed to participants. For example, the first section that participants saw in the coherent version was “Introduction”, whereas for the low coherent version it was “Example topic issue 2” (see materials section above). Experimental manipulation of familiarity was compared to participant’s rated prior knowledge. Supporting the experimental grouping, participants declared having more prior knowledge before the experiment for psychology texts ($M = 5.1$, $SD = 1.84$) than for texts on other disciplines ($M = 2.87$, $SD = 1.59$), $t(54) = 4.82$. Dependent variables included duration of first-pass and second-pass fixations of overview headings and text, in addition to success rate on text-based and inferential questions.

Results

Eye-movements data analyses

First-pass fixations of a critical zone (the five text sections in the overview, and the entire text, see below) were defined as all fixations within the zone during the first reading of it, before moving on or moving back to a different zone. Additional fixations of the zone that occurred later, after at least one other zone had been fixated, were defined as second-pass fixations. As is typical of eye movement data for long text regions, corresponding frequency and duration

Appendix IV

measures were highly correlated. For this reason, we included analyses of the fixations duration only. Before the statistical analyses, eye-movements data were weighted on the basis of the number of characters in each critical zone. Two main zones were considered: the graphical overview and the entire text. For the prior, we first analyzed first-pass and second-pass fixations for the five regions corresponding to the section headings displayed in the overview, and afterwards data was collapsed into a single 'Overview zone' value. This analysis was made independently for each of the five sections of each text. In addition, individual distributions were analyzed in order to detect outliers (fixation times $2 SD$ above or below the participant's mean). Those values (between 1.2% and 2% of data) were replaced by the participant's mean fixation time. For each dependent variable, an ANOVA was performed with familiarity (2), text coherence (2), zone (2) and section order (5) as independent variables. For all analyses, differences declared as significant had $p < 0.05$.

Duration of first-pass fixations. Results for this dependent variable are summarized in table 1. Main effects of familiarity, $F(1,27) = 119$, $MSe = 92.7$; section order, $F(4,108) = 13.7$, $MSe = 63.3$ and zone, $F(1,27) = 2573.4$, $MSe = 481.8$ were observed. As expected, first-pass fixations were longer for unfamiliar texts. In addition, fixations were longer for the text than for the graphical overview. Finally, a linear function described results for section order, $F(1,27) = 34.6$, $MSe = 89.1$. Processing time for text sections decreased as readers advanced through successive sections. Furthermore, significant interactions were found between familiarity and zone, $F(1,27) = 32$, $MSe = 32.6$, and section order and zone, $F(4,108) = 35.9$, $MSe = 58.3$. Two second order interactions help to qualify these results: familiarity, section order and zone, $F(4, 108) = 5.1$, $MSe = 51.4$, and familiarity, section order and text coherence, $F(1,27) = 3.1$, $MSe = 48.6$. Concerning the first second order interaction, results showed that the effect of processing time of section order and zone hold true for unfamiliar texts, $F(1,27) = 36.7$, $MSe = 119.6$, but not for familiars, $F(1,27) = 3.8$, $MSe = 77.9$, $p < 0.1$. That is to say, readers of unfamiliar text devoted more processing time to the graphical overview at the first section encountered, but this pattern reversed on the following ones (second to fifth presented section). By contrast, readers of familiar texts devoted similar processing time to both zones at the first section, and afterwards they focused mainly on the text. Finally, regarding the interaction of familiarity, section order and text coherence, results showed that on the first section presented, readers of familiar texts processed longer the low coherent version, $F(1,27) = 6.1$, $MSe = 34.8$, but no such coherence effect appeared for unfamiliar texts, $F < 1$.

Table 1

Mean first-pass fixation duration as a function of prior knowledge and text coherence, by zone and section order.

	Low Prior Knowledge		High Prior Knowledge	
	Low Coherence	High Coherence	Low Coherence	High Coherence
Overview				
Section 1	40 (11.24)	39.08 (10.9)	29.89 (8.12)	27.81 (8.39)
Section 2	29.42 (10.9)	28.11 (11.47)	20.36 (5.33)	20.09 (8.67)
Section 3	29.79 (8.84)	26.16 (8.32)	21.33 (10.31)	18.92 (7.57)
Section 4	25.88 (10.86)	27.06 (9.16)	18.19 (7.04)	21.09 (11.07)
Section 5	24.8 (11.18)	26.49 (9.15)	18.19 (4.2)	18.81 (10.16)
Text				
Section 1	26.23 (12.81)	27.79 (10.79)	27.31 (11.68)	23.88 (9.53)
Section 2	30.66 (13.17)	33.84 (11.16)	29.58 (9.44)	26.68 (8.99)
Section 3	34.24 (10.51)	29.17 (12.39)	26.34 (7.83)	28.72 (10)
Section 4	32.51 (11.04)	34.67 (12.53)	25.13 (7.6)	22.87 (8.47)
Section 5	30.97 (9.6)	27.71 (11.37)	25.51 (8.46)	28.29 (8.37)

Note. Data are reported in millisecond per character. Standard deviations are provided in brackets.

Duration of second-pass fixations. Results are summarized in table 2. ANOVAs with this dependent variable revealed main effects of familiarity, $F(1,27) = 91.1$, $MSe = 378$, section order, $F(4,108) = 44$, $MSe = 241$, and text coherence, $F(1,27) = 5.5$, $MSe = 470$. The two first were similar than those observed in the analyses with first-pass fixation duration: processing times were longer for unfamiliar texts and a linear decreasing function explained the effect of section order. In addition, regarding the main effect of text coherence, low coherent texts were reprocessed longer than the high coherent ones. Furthermore, significant interactions were found between familiarity and section order, $F(4,108) = 4.8$, $MSe = 244$, familiarity and zone, $F(1,27) = 14.6$, $MSe = 172$, and section order and zone, $F(4,108) = 10.4$, $MSe = 303$. An interpretation of these effects must wait until the mediating effect of a third variable is considered on two significant second order interactions: familiarity, section order and zone, $F(4,108) = 4.2$, $MSe = 202$, and familiarity, section order and text coherence, $F(4,108) = 2.7$, $MSe = 171$. Regarding the first interaction, readers of unfamiliar texts reprocessed longer the overview than the text on the first section presented, $F(1,27) = 26.6$, $MSe = 495.9$, but no difference was found for the subsequent four sections, $F < 1$. By contrast, readers of familiar texts showed no difference for the first two sections, $F(1,27) = 1.5$, $MSe = 347.8$, but longer reprocessing of the text for the later sections (third to fifth), $F(1,27) = 15.3$, $MSe = 242.5$. Finally, concerning the familiarity, section order and text coherence interaction, results showed an effect opposed to that found for first-pass data: on the first section presented

Appendix IV

readers of familiar texts showed no coherence effect, $F < 1$, but readers of unfamiliar texts reprocessed longer low coherent texts than the high coherent versions, $F(1,27) = 6$, $MSe = 579.6$.

Table 2

Mean second-pass fixation duration as a function of prior knowledge and text coherence, by zone and section order.

	Low Prior Knowledge		High Prior Knowledge	
	Low Coherence	High Coherence	Low Coherence	High Coherence
Overview				
Section 1	73.6 (39.67)	56.86 (21.32)	43.95 (24.63)	42.3 (19)
Section 2	42.49 (23.88)	38.42 (19.24)	35.87 (14.52)	31.32 (12.53)
Section 3	37.19 (10.72)	37.07 (13.01)	19.79 (6.19)	25.02 (8.89)
Section 4	41.03 (20.79)	40.41 (19.03)	26.08 (9.04)	16.62 (5.31)
Section 5	37.09 (15.52)	29.1(11.57)	29.52 (17.01)	21.86 (6.79)
Text				
Section 1	46.3 (16.88)	40.78 (18.12)	41.9 (16.7)	38.1 (15.46)
Section 2	37.01 (29.18)	42.88 (20.24)	32.49 (11.96)	28.6 (12.66)
Section 3	44.64 (21.19)	41.24 (19.38)	30.86 (12.26)	30.62 (13.72)
Section 4	40.61 (17.54)	41.22 (16.57)	27.11 (11.21)	28.39 (9.61)
Section 5	35.08 (14.77)	31.09 (13.88)	31.08 (14.94)	30.76 (16.64)

Note. Data are reported in millisecond per character. Standard deviations are provided in brackets.

Comprehension data

Responses for each question were given credit of 0 (incorrect response) or 1 (correct response). Some questions asked to recall two or three facts (e.g. ‘Recall two masterpieces of the Symbolism movement according to the text’). In this case, incomplete responses could be given partial credit (0.5 for those requesting two facts, 0.33 or 0.66 for those asking for three facts). Two raters (the two first authors) coded 20% of the data for a reliability sample. Concordance on the sample data was 91%. Disagreements were all resolved in discussion. One rater (the first author) coded the remainder of the data. Comprehension data was averaged for each four types of text (combination of low and high familiarity, and low and high coherence order), and for each type of question (text-based and inferences).

Before the presentation of the analyses aimed to test our hypotheses, we shall explore a series of ANOVAs intended to assess the effect of familiarity and coherence on comprehension, independently of participant’s overview processing strategies. Regarding text-based questions, results revealed no effects for familiarity, $F(1, 27) = 1.13$, $MSe = 0.07$, $p < 0.3$, text coherence, $F < 1$, or the interaction of both variables, $F < 1$. Participants scored similarly when

Appendix IV

reading familiar high coherent texts ($M = 0.34$, $SD = 0.24$), familiar less coherent texts ($M = 0.37$, $SD = 0.2$), unfamiliar coherent texts ($M = 0.34$, $SD = 0.25$), or unfamiliar less coherent texts ($M = 0.29$, $SD = 0.23$). Similarly, results for inference questions revealed no effects for familiarity, $F(1, 27) = 1.38$, $MSe = 0.03$, $p < 0.3$, text coherence, $F(1, 27) = 2.01$, $p < 0.2$, or the interaction, $F < 1$. Again, participants scored equally when reading familiar high coherent texts ($M = 0.34$, $SD = 0.25$), familiar less coherent texts ($M = 0.31$, $SD = 0.24$), unfamiliar high coherent texts ($M = 0.31$, $SD = 0.19$), or unfamiliar less coherent texts ($M = 0.24$, $SD = 0.18$). These results are not surprising, providing that participants could use overviews in order to overcome comprehension difficulties due to lack of familiarity or low text coherence. Therefore, the critical issue is how overview processing strategies affect comprehension, depending on readers' familiarity and text coherence. We explored this relation through a series of multiple regression analyses. For each of the four sets of data resulting from crossing the variables familiarity (low and high) and coherence (low and high), a multiple regression analysis with the forward stepwise method was performed for each dependent variable (success rate for text-based and inference questions), with first-pass and second-pass fixation duration for the two zones considered (overview and text) as predictors. Section order presentation was not considered here with the aim to keep a trade-off between the informativeness and clarity of the regression formula.

Regression analyses with score on text-based questions clearly supported our hypotheses. For the two high coherence groups, no variable predicted comprehension, whereas for the low coherence groups, the variable second-pass fixation duration of the graphical overview resulted to be the only significant predictor. More concretely, for unfamiliar low coherent texts a positive relation between variables was observed, $\beta = 0.42$, $R^2 = 0.18$, $F(1,26) = 5.73$, whereas for familiar low coherent texts a negative relation aroused, $\beta = -0.5$, $R^2 = 0.25$, $F(1,26) = 8.83$. Readers of unfamiliar low coherently ordered texts devoting more reprocessing time to the overview got better scores on text-based questions. By contrast, readers of familiar low coherently ordered texts devoting less reprocessing time to the overview actually learn more.

Finally, regression analyses with score on inference questions showed a significant regression formula for the familiar high coherently ordered texts, $\beta = -0.53$, $R^2 = 0.28$, $F(1,26) = 10.28$. The formula described a negative relation between second-pass fixation duration of the graphic overview and scores on inference questions. No other predictors resulted significant for this dependent variable.

Discussion

The present work takes part of a research approach that looks to maximize our knowledge on the field of (hyper)text comprehension by looking up at individual differences on strategic processing (Hyönä et al., 2002). Indeed, the use of eye-movement technique helps us to identify key factors affecting visual processing of graphic overviews, and to understand how this processing is related to text comprehension (Rouet & Passerault, 1999).

Factors affecting overview processing

Globally, results support the claim that important factors identified in existing literature on eye-movements and reading linear text such as prior knowledge and coherence also play an important role in processing graphical overviews. Both processing and reprocessing of texts and overviews is longer for unfamiliar texts (Kaakinen et al., 2003; Wiley & Rayner, 2000), and reprocessing is also longer for less coherent texts (Vauras et al., 1992; Rink et al., 2003). Interestingly, results from our study also show several interactions between variables that present a more complex picture of the issue. Concretely, results show that the type of overview used here is processed mainly at early stages of reading. Indeed, while reading the first and second sections of a five-sections text, learners devote more processing time to the overview than to the text itself when the text is unfamiliar, and distribute equally their processing time between both zones when the text is familiar. This effect is consistent with the assimilation theory of Mayer (1979), which states that readers use overviews at the encoding stage to set a fitting schema for the text itself.

Appendix IV

Furthermore, data revealed two interactions between familiarity and coherence at the first section read, for both first-pass and second-pass fixation data. Results show that readers identify macrostructural coherence problems, and thus engage in remediation strategies such as devoting more processing time to overviews (Borkowski, Carr & Pressley, 1987; Roberts & Newton, 2001), at different time points depending on their text familiarity. Immediately after starting reading a new text, readers of familiar topics seem able to identify an incoherently ordered text, thus they devote more processing time (i.e. duration of first-pass fixations) to both the graphical overview and the text than to coherently ordered texts. By contrast, data suggest that readers of unfamiliar topics need more time to identify an incoherent ordered text, so they only devote more time to the ill-ordered materials after a first processing of them (i.e. longer second-pass fixations).

Relation between overview processing strategies and comprehension

Results also give support for a direct relation between visual processing strategies of overviews and learning from text. As expected, overview processing is particularly important for learning in low coherently ordered texts (Mayer, 1978, 1979). This could be the fact of most hypertext reading, provided that a coherent order is not systematically followed by a majority of these readers (Salmerón, Kintsch & Cañas, in press). Data of our experiment reveal that readers of unfamiliar texts that reprocess the graphic overview during more time end up comprehending the text better (measured by text-based questions), which suggests that readers use the macrostructural information from overviews as a base for their representation of the text (Goldman, 1996). By contrast, an opposite effect holds for familiar texts, which suggest that a ‘long reprocessing strategy’ (i.e. longer second-pass fixations in the graphical overview) prevents readers with existing knowledge from activating it to fully comprehend a text (Shapiro, 1998).

In addition, results show that for familiar high coherently ordered texts overview reprocessing is negatively related to comprehension, as measured by inference questions. Two explanations might be considered for understanding this unexpected result: a problem of knowledge activation, or a signal of miscomprehension. A first explanation could be that this result just revealed a lack of activation of existing knowledge, as was considered the case for low coherent texts. Readers reprocessing an overview more time might be learning less because their reprocessing strategy prevented them from using their existing knowledge. However, from a theoretical point of view, readers of familiar texts are not induced to engage in an active processing of text by a high coherently ordered text (McNamara et al., 1996; McNamara & Kintsch, 1996; Schnotz, 1982). Either if readers just focus on the text (i.e. less reprocessing of the overview) or if they reprocess longer the overview, they would not necessarily further activate their existing knowledge, at least not to the extent to which they will when reading an incoherently ordered text. Therefore, learning differences observed might not be associated to a disparity in knowledge activation. A second explanation is that the fact that readers learning less reprocessed for longer the overview might be interpreted as a miscomprehension signal. In other words, these readers could have experienced comprehension problems during their reading, thus they tried unsuccessfully to understand from the overview the miscomprehended parts. It is interesting to note that this effect holds only for inference questions, intended to assess comprehension at the situation model level (i.e. a representation of what the text is about that integrates the information with readers’ prior knowledge). The fact that readers mainly rely on that representation in order to monitor their comprehension during reading (Rawson, Dunlosky, & Thiede, 2000), and not on the representation assessed by text-based questions (i.e. the textbase, a hierarchical propositional representation of the information within the text), gives some support to this interpretation.

Suggestions for future research

Given the correlational nature of the analyses relating processing and learning, we should be cautious about the conclusions drawn here. In order to clarify the nature of the unexpected effect on the negative relation between duration of second-pass fixations and inference questions for familiar coherent texts, the eye-movements technique could be

Appendix IV

combined with a think aloud procedure (Kaakinen & Hyönä, 2005). If the 'miscomprehension' explanation for this effect were true, readers of familiar high coherently ordered text reprocessing for longer the overview might express more comprehension troubles on the think aloud protocols than those reprocessing less the overview.

Future research might also explore the role of the variables studied here with other types of text devices for conveying text structure, such as networked overviews or constellations. In this type of device, semantic (e.g. causal) relations between main topics are displayed. Some authors have proposed that network maps might enrich the mental representation of hypertext readers with prior knowledge by increasing the connectivity within their text mental representation (Hofman & van Oostendorp, 1999; Potelle & Rouet, 2003). Nevertheless, empirical studies relying on off-line measures of comprehension have failed to validate this claim. The use of the eye-movements technique might provide additional information in order to test such claim.

References

- Borkowski, J., Carr, M., & Pressely, M. (1987). "Spontaneous" strategy use: perspectives from metacognitive theory. *Intelligence, 11*, 61-75.
- Britton, B. K. (1994). Understanding expository text: building mental structures to induce insights. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 641-674). San Diego: Academic Press.
- Charney, D. (1994). The impact of hypertext on processes of reading and writing. In S. J. Hilligoss & C. L. Selfe (Eds.), *Literacy and Computers*. New York: MLA.
- Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research, 68*, 322-349.
- DeStefano, D., LeFevre, J-A. (in press). Cognitive load in hypertext reading: A review. *Computers and Human Behavior*.
- Fritz, G. (1999). Coherence in hypertext. In W. Bublitz, U. Lenk & E. Ventola (Eds.), *Coherence in spoken and written discourse: how to create it and how to describe it* (pp. 221-232). Amsterdam, Philadelphia: John Benjamins.
- Garner, R., Alexander, P. A., Slater, W., Hare, V.C., Smith, T., & Reis, R. (1986). Children's knowledge of structural properties of expository text. *Journal of Educational Psychology, 78*, 411-416.
- Gilabert, R., Martinez, G., & Vidal-Abarca, E. (2005). Some good texts are always better: Text revision to foster inferences of readers with high and low prior background knowledge. *Learning and Instruction, 15*, 45-68.
- Goldman, S. R. (1996). Reading, writing, and learning in hypermedia environments. In H. van Oostendorp & S. de Mul (Eds.), *Cognitive aspects of electronic text processing* (pp. 7-42). Norwood, NJ: Ablex.
- Hofman, R., & Van Oostendorp, H. (1999). Cognitive effects of a structural overview in a hypertext. *British Journal of Educational Technology, 30*, 129-140.
- Hofmann, T. R. (1989). Paragraphs, & anaphora. *Journal of Pragmatics, 13*, 239-250.
- Hyönä, J., Lorch, R. F. & Kaakinen, J. K. (2002). Individual differences in reading to summarize expository text: evidence from eye fixation patterns. *Journal of Educational Psychology, 94*, 44-55.
- Kaakinen, J. K. & Hyönä, J. (2005). Perspective effects on expository text comprehension: evidence from think-aloud protocols, eyetracking, and recall. *Discourse Processes, 40*, 239-257.
- Kaakinen, J. K., Hyönä, J. & Keenan, J. M. (2003). How prior knowledge, WMC, and relevance of information affect eye fixations in expository text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 447-457.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.

Appendix IV

- Kintsch, E., & Kintsch, W. (1995). Strategies to promote active learning from text: individual differences in background knowledge. *Swiss Journal of Psychology*, 54, 141-151.
- Lorch, R. F., & Lorch, P.E., 1996. Effects of organizational signals on free recall of expository text. *Journal of Educational Psychology*, 88, 38-48.
- Lowerse, M. (2001). An analytic and cognitive parameterization of coherence relations. *Cognitive Linguistics*, 12, 291-315.
- Mayer, R. E. (1978). Advance organizers that compensate for the organization of text. *Journal of Educational Psychology*, 71, 880-886.
- Mayer, R. E. (1979). Twenty years of research on advance organizers: Assimilation theory is still the best predictor of results. *Instructional Science*, 8, 133-167.
- McNamara, D. S., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interaction of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1-42.
- McNamara, D. S., & Kintsch, W. (1996). Learning from text: effect of prior knowledge and text coherence. *Discourse Processes*, 22, 247-288.
- Naumann, A., Waniek, J. & Krems, J. F. (2001). Knowledge acquisition, navigation and eye movements from text and hypertext. In U. D. Reips & M. Bosnjak (Eds.), *Dimensions of Internet Science* (pp. 293-304). Lengerich, Germany: Pabst.
- Potelle, H., & Rouet, J.-F. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies*, 58, 327-345.
- Rawson, K. A., Dunlosky, J., & Thiede, K. W. (2000). The rereading effect: Metacomprehension accuracy improves across reading trials. *Memory & Cognition*, 28, 1004-1010.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124, 372-422.
- Rink, M., Gámez, E., Díaz, J. M., & de Vega, M. (2003). Processing of temporal information: evidence from eye movements. *Memory & Cognition*, 31, 77-86.
- Roberts, M. J., & Newton, E. J. (2001). Understanding strategy selection. *International Journal of Human-Computer Studies*, 54, 137-154.
- Rouet, J.-F. & Passerault, J.-M. (1999). Analyzing learner-hypermedia interaction: An overview of online methods. *Instructional Science*, 27, 201-219.
- Salmerón, L., Cañas, J. J., Kintsch, W., & Fajardo, I. (2005). Reading strategies and hypertext comprehension. *Discourse Processes*, 40, 171-191.
- Salmerón, L., Kintsch, W. & Cañas, J. J. (in press). Reading strategies and prior knowledge in learning with hypertext. *Memory & Cognition*.
- Schmid, S. & Baccino, T. (2002). Perspective-shift effect and text format: An eye-tracking study. *Current Psychology Letters, Behaviour, Brain & Cognition*, 9, 73-87.
- Schnotz, W. (1982). How do different readers learn with different text organizations? In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 87-97). Amsterdam: North-Holland.
- Shapiro, A. M. (1998). Promoting active learning: The role of system structure in learning from hypertext. *Human-Computer Interaction*, 13, 1-35.
- Shapiro, A.M., & Niederhauser, D. (2004). Learning from hypertext: research issues and findings. In D.H. Jonassen (Ed), *Handbook of Research on Educational Communications and Technology*, 2nd Ed. (pp 605-620).

Appendix IV

Mahwah, NJ: Lawrence Erlbaum Associates.

Soederberg Miller, L. M., & Stine-Morrow, E. A. (1998). Aging and the effects of knowledge on on-line reading strategies. *The Journals of Gerontology*, 53B, 223-233.

Unz, D. C., & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, 20, 279-295.

Vauras, M., Hyönä, J., & Niemi, P. (1992). Comprehension coherent and incoherent texts: Evidence from eye movement patterns and recall performance. *Journal of Research in Reading*, 15, 39-54.

Voss, J. F., & Silfies, L. N. (1996). Learning from history text: the interaction of knowledge and comprehension skill with text structure. *Cognition and Instruction*, 14, 45-68.

Waniek, J., Brunstein, A., Naumann, A., & Krems, J. F. (2003). Interaction between text structure representation and situation model in hypertext reading. *Swiss Journal of Psychology*, 62, 103-111.

Wiley, J. & Rayner, K. (2000). Effects of titles on the processing of text and lexically ambiguous words: Evidence from eye movements. *Memory & Cognition*, 28, 1011-1021.