Effects of valence and causal direction in the emotion inferences processing during reading: Evidence from a lexical decision task

José A. León[1]*, María T. Dávalos[2], Inmaculada Escudero[3], Ricardo Olmos[1], Yurena Morera,[4] & Manuel Froufe[1]

1 Universidad Autónoma de Madrid (Spain).
2 Universidad Nacional de Zapatecas (México).
3 UNED (Spain).
4 Universidad de La Laguna (Spain).

Abstract: In two experiments we investigated the role that activation of emotional inferences when readers represent fictional characters' emotional states using an affective lexical decision task. Subjects read short stories that described concrete actions. In the first experiment, we analyzed whether the valence (positive or negative) was an important factor of inference´s activation. The results showed that valence was determinant factor in the moment that emotional inference was generated, being the positive valence faster than negative. In the second experiment we studied whether the emotion inference activation was influenced by the causal direction of the story, where the causal direction of the text was manipulated in order to induce towards an emotional inference predictive (the reader looking for a consequence that promote a particular emotion) or inducing an explanatory inference (reader looking for a cause that "explain" a particular emotion). The results suggest that emotional inferences are made online, and that valence and causal directions are two decisive components of emotional trait, but only positive valence increase their processing.
Key words: Emotional inferences; emotional valence; causal direction; lexical decision task; explanatory inference: predictive inference.

Título: Efectos de la valencia y la dirección causal en el procesamiento de inferencias emocionales durante la lectura: Evidencia mediante una tarea de decisión léxica.
Resumen: En dos experimentos se investigó el papel que juega la activación de inferencias emocionales cuando los lectores representan estados emocionales de los personajes ficticios mediante una tarea de decisión léxica. Los participantes leyeron historias cortas que describían acciones concretas. En el primer experimento se analizó si la valencia emocional (positiva o negativa) influía en la activación de la inferencia. Los resultados mostraron que la valencia fue factor determinante en el momento en que se generaba la inferencia emocional, siendo la valencia positiva más rápida que la negativa. En el segundo experimento se analizó la dirección causal de la historia, donde en un caso fue manipulada para inducir hacia una inferencia emocional predictiva (el lector busca una acción que anticipa una emoción particular), y en otro explicativa (el lector busca una causa que "explique" una emoción en particular) y si estas dos condiciones diferían en la activación de la inferencia emocional. Los resultados revelaron que las inferencias emocionales se hacen de manera automática en ambos estudios y que tanto la valencia como la dirección causal se consideran componentes básicos de las inferencias emocionales, pero sólo la valencia positiva acelera aún más el procesamiento del rasgo emocional.
Palabras claves: Inferencias emocionales; valencia emocional; tarea de decisión léxica; inferencia explicativa; inferencia predictiva; dirección causal.

Introducción

The generation of inferences is a mental activity as complex as necessary for the comprehension processes of the daily life. This mental activity is considered to be fundamental due to the high adaptative value that inferences possess to predict behaviors, to understand the reality. Thanks to the inferences we can reveal the implicit of the language, making it explicit, or to read between the lines (León, 2003). We might affirm that any information that is obtained from our experience and is not explicited in the text, can be considered to be an inference (McKoon and Ratcliff, 1992).

Regarding the discourse comprehension, the inferences are identified by mental representations that the reader constructs when he tries to understand the message, substituting, adding or integrating information explicited in the text. This idea is supported by the existence of a linguistic process called top – down (see Kintsch, 2005; Garton and Pratt, 2004). According to this model of linguistic processing, the comprehension begins extracting information from the more global aspects of the text, such as the title or the basic idea of the paragraph (Lorch, Lemarié and Chen, 2013), to other specifics (smaller linguistic units like clauses and words) and all this orientated from the previous knowledge of the reader, that is, is our previous experience the one that "guides" our process of comprehension (Cevasco and van den Broek, 2013). Some authors indicate that the top - down processing develops from very early age (Angosto, Sánchez, Álvarez and León, 2013; Kendeou, van den Broek, White and Lynch, 2007).

During the last decades, there has been an increasing interest on the study of a type of inferences, the emotional inferences, which are the inferences that the readers construct about the emotions of the characters of the history, covering an important area of research on text comprehension (e.g., Gernsbacher, Goldsmith and Robertson, 1992; de Vega, León and Díaz, 1996; Dávalos and León, 2013). Along a history, the characters are involved in different situations that lead them to demonstrating a map of emotions, in some occasions revealed of explicit form (e.g., Manuel felt deep sadness on having found out that his father had died), and in others, of implicit form (e.g., Manuel felt a knot in the throat on having found out that his father had died). In this case, the emotions are deduced across the reading of the context that involves the character, playing a very important role in the coherence of the text (Miall, 1989). From this point of view, it is assumed that emotional inferences take part in the mental representation of the text, as a guide that orientates

* Correspondence address: José A. León. Dpto de Psicología Básica. Facultad de Psicología. Avda de Pavlov, 6. Campus de Cantoblanco. Universidad Autónoma de Madrid. 28049, Madrid (España). E-mail: joseantonio.leon@uam.es

the comprehension of the text, helping to support a global coherence (Graesser, Singer and Trabasso, 1994).

Research on comprehension suggests that readers are able to construct mental representations on specific dimensions, such as space, causality or temporality (see León, 2003, for a review) or also on specific domains like clinical psychology (León and Pérez, 2001). Nevertheless, we find very few studies that investigate on how the emotional inferences are generated and under what components are activated. Up to the moment, the studies centred on this topic indicate that the readers can infer the emotional conditions of the protagonists while they read, and that the activation of these inferences can be generated in an automatic way, that is, during the same process of reading (*on-line*) (Gernsbacher, Goldsmith and Roberston, 1992; Gernsbacher and Roberton, 1992). But, on the other hand, there is no agreement about what basic components produce them. Whereas some authors assume that the emotional inferences possess a major degree of specificity than other inferences more dependent on the syntactic clauses like the anaphoras (e.g., Gernsbacher, Goldsmith and Roberston, 1992; Gernsbacher and Roberton, 1992; Gernsbacher, Hallada and Roberston, 1998) for others, this specificity does not exist, finding more general factors (as the valence) that really influence the level of activation (e.g., Gygax, Oakhill and Garnham, 2003; Gygax, Garnham and Oakhill, 2004; Gygax, Tapiero and Carruzzo, 2007). In this regard, some results show that the valence (positive or negative) influences the activation of an emotional inference (Gygax et al., 2003, 2004 and 2007). These authors have detected systematically an asymmetric effect in the activation of the emotional inferences depending on their valence, being positive inference processes faster than the negatives. These results suggest that the negative emotions, having been negative social stimuli, in many cases, by interpersonal problems, need of a major observation or analysis to be identified and to give a suitable response (Taylor, 1991) or also that the negative thing produces longer, more consistent thoughts, more multifaceted or of more lasting effect (Baumeister, Bratslavsky, Finkenauer and Vohs, 2001).

There exists some evidence of the effect of the valence in another type of tasks like, for example, *emotional Stroop*. Different authors have shown that participants invest more time in naming the color of the ink for the negative stimuli than for the positives (e.g., Keil and Ihssen, 2004; Keil, Ihssen and Heim, 2006; Pratto and John, 1991). These results suggest that the subjects use more time in processing the negative thing because they look of more detailed form for the meaning of these stimuli. Another task commonly used is recall, where a person is asked to remember some personal positive and/or negative experience. In this case, the negative recall are in the habit of being described by major detail that the positives, owed probably to that the positive recalls are in the habit of being simpler and they tend to be more mixed thoughts (Aguado, 2005). These results suggest that the emotion with negative valence is processed more me-

ticulously when it is being codified and, probably due to this, it is retained in a more complex and elaborated form in the memory (Robinson-Riegler and Winton, 1996), being able to indicate a major conscious processing (Ohira, Winton and Oyama, 1997).

Another component that is assumed to be essential for the inferencial processing is the causal structure. Research on discourse comprehension distinguishes between two types of causal inferences: the explanatory inferences (also named causal antecedents) and the predictive inferences (also named causal consequence inferences). Both types of inferences have been widely studied (e.g., Coté, Goldman and Saul, 1998; Escudero and León, 2007; Fincher-Kiefer, 1996; Graesser and Bertus, 1998; León and Pérez, 2001; Millis and Graesser, 1994; Singer 1994; Singer and León, 2007; Trabasso and Magliano, 1996). In a general way, it can be considered that the explanatory inferences are those that are generated when the reader connects a sentence with his previous knowledge (Millis and Graesser, 1994; Magliano et al., 1993), when he explains why the actions or emotions happen (Graesser et al., 1994). The predictive inferences express predictions, results or possible consequences about what will come later (Millis and Graesser, 1994; Magliano et al., 1993). Let us consider the following sentences as an example: *Carlos prepared a leg of lamb to roast it to the oven, he introduced it in the oven and putted it to 200 degrees. Two hours later, he had remained slept in the sofa seeing a football match*. When the reader reads the last sentence, he can predict that the roast is going to be burned, generating a predictive inference, a supposition that something can happen in the immediate future. Otherwise, the reader also can generate another inference in case he needs to provide with coherence or explanation of an incomplete information. Let's suppose, for example, that the last sentence of the previous example is *Two hours later, Carlos detected a strong smell to burned coming from the kitchen*. In this case, the reader can infer that the roast has burned. This supposition constitutes an explanatory inference, which object is to look for a reason or explanation of the appearance of the strong smell to burn.

These causal inferences have been widely studied. The comparison between them (*explanatory* vs. *predictive*) suggests that the explanatory inferences are generated before than the predictive ones (e.g., Graesser, Haberlandt and Koizumi, 1987; Potts et al., 1988; Singer and Ferreira, 1983). One of the reasons argued is related to the own nature of the inferential process, strongly determined by the search of a global coherence of reading. Thus, while it is assumed that the explanatory inferences "repair" the coherence absence of reading as one of their more typical properties, the same thing does not happen with the predictive inferences (e.g., Black and Bower, 1980; Graesser, 1981; Graesser and Clark, 1985; León, 2009; León and Peñalba, 2002, Singer et al., 1992; van den Broek, 1990a, 1990b).

These causal inferences can be analyzed also from the emotional inferences. The causal structure of a history also turns out to be essential to understand the emotions of the

protagonists (Komeda and Kusumi, 2006; Liu, Karasawa and Weiner, 1992). The emotional inferences can explain or predict the possible reactions of the characters. This explanation or anticipation helps to establish a logical and coherent mental representation of the story and helps to support the on-line comprehension process. For this representation, the reader needs to connect not only the causal elements and motivations of a character, but also, the non-verbal and emotional implicit elements involved. Thus, the reader constructs previously an emotional state and can produce one or more probable consequences. In this sense, the emotions offer a pre-structure of the global meaning of the text (Miall, 1989). Thanks to this, it is possible to analyze the activation of an emotional inference attending to its causal directionality, distinguishing between causal explanatory inference, which establishes the reason or why there arises certain emotion (e.g., *Manuel felt deep sadness... (because) … he found out that his father had died*) and causal predictive inference, which anticipates the possible consequences or emotion (e.g., *Manuel on having found out that his father had died …, (as consequence) … felt deep sadness*).

Objectives of this study

In this study, both components of the emotions are analyzed: the effect of the valence in the activation of the emotional inference (analyzed in the experiment 1) and the effect of the causal direction (experiment 2). With regard to the first experiment, we intended to determine if the emotional inference is realized in an automatic way (*on-line*), below the 750 ms., using a lexical decision task. In this experiment we tried to analyze, in addition, if the effect of the valence (positive, negative) facilitates the generation of the emotional inference. Hereby, we wanted to confirm the hypothesis of which the emotional inferences with positive valence are activated before the negative valence, as some authors indicate (Gygax, Garnham and Oakhill, 2004; Gygax, Oakhill and Garnham, 2003; Gygax, Tapiero and Carruzzo, 2007). In this direction, we expect to find that the reaction times of the emotional inferences (*related target*) with positive valence are significantly faster than the related target with negative valence.

The second aim of this study was to determine if the causal direction (*cause–emotion* vs. *emotion-cause*) influences equally the generation of the emotional inference, using the same lexical decision task (experiment 2). To do it, we modified the causal direction of the histories. Few histories induced the reader to generate explanatory inferences (*to establish why*), whereas others induced them to generate predictive inferences (*to anticipate the emotion of the character*). Because in previous studies the antecedent causal inference was faster than its consequence (Singer and León, 2007), our hypothesis is that the cause of the inference that explains the emotional reaction (*explanatory inference*) will be activated before that the search of the anticipation of the character (*emotional predictive inference*).

Experiment 1

Authors like Miall (1989) propose that the emotions possess diverse important functions in a history. One of them stands out the fact that an emotion is auto-referential, this is, the reader "identifies" with the experiences and motivations of the characters, and thanks to it the reader can access to his own information and uses it to share the goals and the feelings of the character. This implies that the interpretation of the text is wide and varied, since the reader influences and gives sense to the elements of the text from his previous experiences, which take it to empathy - or not - with the character (Komeda, Kawasaki, Tsunemi and Kusumi, 2009; Komeda and Kusumi, 2006) and therefore, not only codify the intentions of the characters, but also his own preferences on the topic (Rapp and Gerring, 2002). The emotions also possess a second function, that is, allowing to establish a categorization of the elements of the text. The sentences or phrases that have been evaluated initially in terms of importance by their meaning (e.g., specifying the scenes of the history) can be re-evaluated or re-categorized with new information (e.g., the relations between the characters). The emotional valence is really important in this re-evaluation.

With these assumptions, in this first experiment we tried to analyze, on the one hand, if the emotional inferences were activated automatically (*on-line*) and, for other one, if the effect of the valence (*positive, negative*) was influencing the facilitation of the emotional inference during the comprehension, using a lexical decision task. In case the valence (*positive* or *negative*) was not facilitating the activation of the inference or was not generated in an automatic way (*on-line*) through a of lexical decision task, then: a) the global reaction times will be higher than 750 ms. (McKoon and Ratcliff, 1992). On the other hand, if the prediction of which the activation of a positive emotion was not generating faster than the negative one, will not appear significant differences in the reactions times between the target of positive valence and the negative one. For this study we used a lexical decision task with a 500 ms. SOA and three types of target (*Related*, *Non-related* and *Non-word*). The incorporation of Non-word becomes necessary to test the lexical decision task.

Method

Participants

Seventy-four students of the Faculty of Psychology of the Universidad Autónoma of Madrid took part voluntarily in this study.

Materiales y estímulos

For this experiment we used a total of 88 texts: 68 experimental (28 positives and 40 negatives) and 20 neutral texts. In addition, we used two practice texts (see Table 1). The

neutral histories were not inviting the generation of any emotional inference. These histories were describing some daily situation, and they were not followed by a target or comprehension question.

Table 1. Positives and negatives histories used in the experiment 1.1.

POSITIVE VALENCE

Margaret wants to study in the university.
Today she received a letter from the Rectorate.
They notify to her that she is admitted. (CRITICAL SENTENCE)
Margaret feels...

Conditions:
Related: HAPPY
Non-Related: LOVER
Non-Word: RELAZO

Question: ¿Does Margaret want to study?

NEGATIVE VALENCE

Cándido has a faithful dog who accompany him.
Today in the morning, he went to the garden.
He discovered that his dog was dead. (CRITICAL SENTENCE)
Cándido feels…

Conditions:
Related: SAD
Non-Related: JOKE
Non-Word: ASCRAS

Question: ¿Did Cándido have a cat?

Procedure

Before beginning the lexical decision task participants were given oral and written instructions. Instructions asked participants to decide as soon as possible if the word that was appearing immediately after the text was or not a word with meaning. The examples appeared just before beginning the experimental task. We use DMDX as experimental software (Forster and Forster, 2003). All the texts were presented in the computer screen. Participants must press YES or NOT from the keyboard. Each history was presented sentence by sentence (at a 126 ms. rate per syllable) in the center of the screen. Concluded the time for every sentence, this one was eliminated and replaced with the following sentence; after eliminating the last sentence (fourth) an interval of 225 ms. was appearing in white, a line of asterisks in the center of the screen during 50 ms. and again an interval in white of 225 ms. (SOA of 500 ms.). Immediately the target was appearing (related or not related to the experimental condition). Reaction times were registered, between the appearance of the target and the pressure of the key YES or NOT. Later, the comprehension question was appearing and, once again, participants had to answered YES or NOT.

The following text began immediately after the answer (20 minutes approximately).

Design

The initial data was filtered under two criteria: a) we eliminated data when comprehension responses error rate was higher than 25 %, and b), we eliminated reaction times data with a 2,5 standard deviation above or below the average (.09 % with positive valence and .86 % with negative valence). An ANOVA was realized to confirm the results of the lexical decision task (*word* vs. *non-word*). Considering that the length of the target between with positive valence (28 texts) and negative valence (40 texts) showed a significant difference (t $(2,964) = 3.16$; $p <.01$), we did an ANCOVA 2 (target: *related* vs. *non-related*) x 2 (valence: *positive* vs. *negative*). The covariable is the word length and the dependent variable is the reaction times.

Results and discussion

The reaction times for the word were significantly lower to the non-word (F $(1,4564) = 194.82$; $MSE = 113224.9$; $p <.05$), that confirms the correct functioning of the lexical decision task. About the second analysis (ANCOVA 2x2), we observe that the emotional inference (related target) showed significantly lower reaction times comparing the non-related target (F $(1,1526) = 290.51$; $MSE = 68523.9$; $p <.05$). In addition, results shows that the positive valence is activated significantly faster than the negative one (F $(1,1526) = 9.43$; $MSE = 68523.9$; $p <.05$). With these results we can suggest that emotional inferences with positive as negative valence are activated on-line (see Figure 1). Nevertheless, there is a clear difference of the positive valence (p.e., Baumeister, Bratslavsky, Finkenauer and Vohs, 2001). We founded similar results regarding the context of the history (positive or negative emotional context). When we compare the related target (*inference*) in a positive (*happy*) condition with other non- related (*lover*) and, in the same way, the related target (*inference*) in a negative (*sad*) condition with other non-related (*thanks*), the activation pattern is the same. The non- related word is activated significantly faster in a positive emotional context than in a negative emotional context (see Figure 1). This shows the strong effect of the valence, which not only can affect the emotional target, but also to the context (positive or negative).

These results support the idea that the valence constitutes a basic component of emotion and, in addition, that the activation of the emotional inference activation is automatic (on-line), below 750 ms. Furthermore, these results show that the emotional inference with positive valence is activated significantly faster that the emotional inference with negative valence, confirming the results obtained by other authors (Gygax, Garnham and Oakhill, 2004; Gygax, Oakhill and Garnham, 2003; Gygax, Tapiero and Carruzzo, 2007).
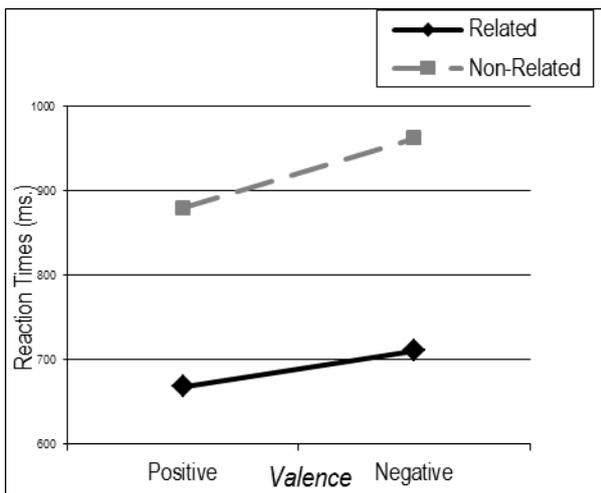
Figure 1. Mean of reaction times in miliseconds (ms.) according to the target (Related vs. Non-related) and the valence (Positive vs. Negative).

Experiment 2

The second aim of this study was to determine if the causal direction (*reason–emotion* vs. *emotion-reason*) influences equally the generation of the emotional inference, using also a lexical decision task. As we know, the emotions have an important explanatory and predictive function. Thanks to the emotional inferences, readers can predict the possible reactions of the characters or explain why things happen. This helps to stablish a coherent mental representation and to construct the global meaning of the text. Thus, we can assume that the causal structure (*cause-effect*) is essential to understand the emotional state of the character.

In our case we wanted to analyze how the causal structure of the history was influencing the generation of the emotional inference. We modified the causal direction of the histories; while one condition was inducing the reader to generate an explanatory emotional inference (to establish why), the other one was inciting the reader to generate a predictive emotional inference (to anticipate the emotion of the protagonist). Provided that in previous studies the causal explanatory inference is faster than the predictive one (e.g., Graesser, Haberlandt and Koizumi, 1987; Potts et al., 1988), our hypothesis is that the reason of the inference that explains the emotional reaction (causal explanatory inference) will be activated before that the search of the anticipation of the protagonist (causal predictive inference). In this experiment we maintained the valence of the emotion, like in the experiment 1, to evaluate if the positive valency exercises also here some influence on the activation of the inference.

Method

Participants

Sixty-five Psychology students from the Universidad Autónoma of Madrid took part voluntarily in this study.

Materials

A total of 156 texts were used: 68 explanatory causal texts (40 negative valences and 28 positive valences), 68 predictive causal texts (40 negative valences and 28 positive valences) and 20 neutral texts. In this experiment, the inference had the role of being both causal explanatory and predictive, also keeping the valencia (positive or negative) as in the previous study. Each text contained a unique emotional situation (see table 2).

Table 2. Example of texts used in experiment 2

Causal Inference EXPLICATIVE
Cándido has a faithful dog who acompany him. Today in the morning, he went to the garden. Cándido feels sad. (CRITICAL SENTENCE) He discovers that his dog is…
Conditions: Related: DEAD Non-Related: FRIENDS Non-Word: IMAGAS
Question: ¿Did Cándido have a cat?

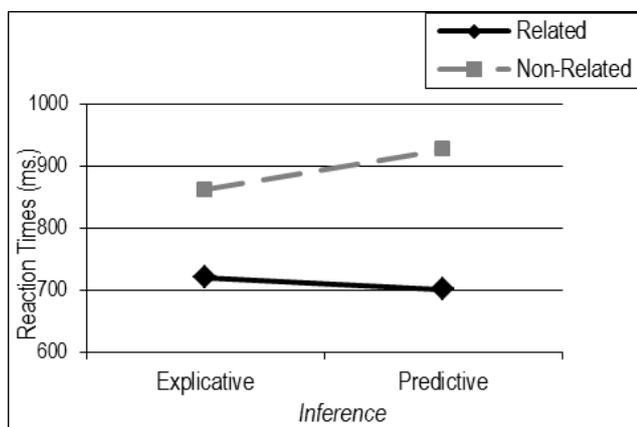| Causal Inference PREDICTIVE |
|---|
| Cándido has a faithful dog who acompany him. Today in the morning, he went to the garden. He discovered that his dog was dead. (FRASE CRÍTICA) Cándido feels… |
| Conditions: Related: SAD Non-Related: FRIENDS Non-Word: IMAGAS |
| Question: ¿Did Cándido have a cat? |

Design

Data was filtered like in the previous experiment. In this case, .38 % of actions and emotions with positive valence, and .82 % of actions and emotions with negative valence were eliminated. Again, an ANOVA was realized to confirm the results of the lexical decision. Provided that the differences were kept in the length of the target in the 28 positive texts and 40 negatives (t (2,959) = 2.96; p <.01), we runned two ANCOVAs: a) ANCOVA 2 (target: *related* vs. *non-related*) x 2 (direction: *explanatory* vs. *predictive*) and b), ANCOVA 2 (target: *related* vs. *non-related*) x 2 (direction: *explanatory* vs. *predictive*) x 2 (valence: *positive* vs. *negative*).

Results y discussion

The reaction times in the word condition were significantly lower than in the non-word condition (F (1,2624) = 193.52; MSE = 113232.8; p <.05). Once again, we con-

José A. León et al.

firmed the good functioning of the lexical decision task. The results of the ANCOVA 2x2 showed, first, that the reaction times of the related target were significantly lower than the non-related (F (1,2618) = 293.29; MSE = 73708.4; p <.05). Thus, we can affirm that the emotional inferences are generated automatically. Secondly, we didn´t find statistically significant differences in relation to the factor of directionality of the history (F (1,2618) = .75; MSE = 73708.4; p = .38), in spite of average of reaction times of predictive inferences (*cause - emotion*) are lower than the explanatory inferences (*emotion- cause*).

In addition, we didn't find significant differences in the non-related words. Nevertheless, there exists a significant interaction between the target and the causal direction (F (1,2618) = 15.4; MSE = 73708.4; p <.05). This effect of interaction is due to the inverse trend of both variables analyzed. On the one hand, in the related target condition, the predictive causal inference is slightly faster than the explanatory causal inference. On the other hand, this trend is inversed when we introduce the non-related target condition. This interaction can be interpreted as a major awareness and dependence of the activation of the emotion with regard to the context that involves it. In this regards, a coherent context increases its activation, whereas an incoherent context delays in excess its activation. This effect of the context has less importance when we are analyzing the search of the cause that produces the emotion (explanatory). Another possible explanation of the interaction comes from the search of the reason that explains it. In a non-related context, it is activated faster, presumably because it can be discriminated before being out of coherence (see Figure 2).

Figure 2. Significant interaction between target (Related vs. Non-related) and causal direction (EXPLICATIVE causal inference vs. PREDICTIVE causal inference).

Finally, the ANCOVA 2x2x2 shows that the average reaction times between the related target were significantly lower than the non-related (F (1,2614) = 293.08; MSE = 73408.5; p <.05). As for the causal direction of the history, once again, we didn't find statistically significant differences between both (F (1,2614) = 12.12; MSE = 73408.5; p = .30).

Nevertheless, when we incorporate the valence factor in the ANCOVA, results show a different pattern of activation. In this case, we can observe that both in the predictive inference and in the explanatory, the positive valence is generated faster than the negative one (F (1,2614) = 5.64; MSE = 73408.5; p <.05).

When we analyze data according to direction, in the emotional inference the positive valence is activated significantly faster than the negative in both targets (*related* and *non-related*), confirming the results obtained in the experiment 1. Even, the effect of the valence is so forceful that again it influences the context that frames to the predictive inference (see Figure 3, graph corresponding to the predictive inference). Even, the effect of the valence is so forceful that, again, it influences the context that frames to the predictive inference (see Figure 3, second graph corresponding to the predictive inference). On the other hand, as we can observe in the graph corresponding to the explanatory inference, data with negative valence, especially in the non-related target, present a longer slope, principally when the negative context pairs off with the search of the emotion (predictive inference) and not with the cause or reason (explanatory inference). Once again, the valence not only influences the emotional target, but also the facilitator context of the activation. As for the direction that induces to an explanatory causal inference (search of the reasons that unleash the emotion), the positive valence is activated significantly faster than the inference with negative valence when the target is related to the history. Nevertheless, in the non-related target, this activation pattern is different: the negative valence tends to be generated faster than the positive valence. We find a triple interaction effect between the valence, target and direction (F (1,2614) = 5.74; MSE = 73408.5; p <.05). This interaction effect can be observed by the inverse trend in the non-related target condition in the negative valence and in case of the explanatory inference. In other words, the reader rejects faster the reason when a non-related target appears when the emotion is of negative valence than when it is positive, being this difference statistically significant (p <.05). This is the only case in which the processing of a context with negative valence is realized significantly faster than the positive.

Based on these results it can suggest that when the reader comes to understand short emotional stories, so quick and important is to search for the explanation of the why certain events and actions occur, as when the reader infers the emotional reaction of the character of the story as a result of a fact or event that produces it. Since we did not find significant differences between emotional inference predictive and explanatory causal inference, are not confirmed previous studies. For example, Singer and León (2007) suggest that the explanatory causal inference is faster (and online) to the predictive causal inference (*off-line*) to expository and narrative contexts not emotional. These results can be explained by the degree of context´s constriction. Predictive inference is located within a very restricted and closed,

context where fit very few possible emotions. Before reading, say, of the critical phrase... *The dog was dead, he felt... (sorry)*, emotional inference prediction is very constrained, which

facilitates its processing, which was not the case in previous studies, where the forecast was more open (Singer and León, 2007).
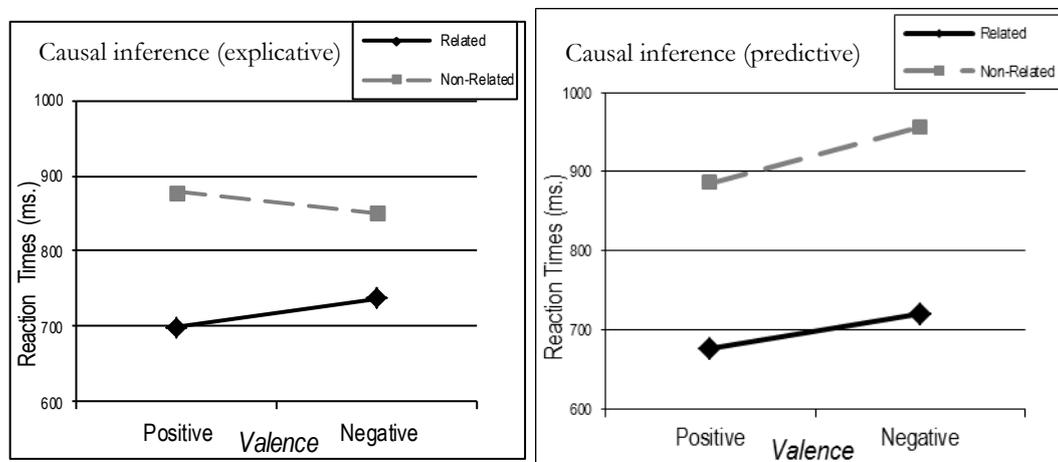
Figure 3. Reaction times in function of target (related vs. non-related) and valence (positive vs. negative) related to causal direction: explanatory causal inference (graph to the left) and causal predictive inference (graph to the right).

Nevertheless, in case of the explanatory causal inference, the context is not so constrained. This is the case …. *He felt sad because his dog was* …, different possibilities can justify Cándido's sadness (e.g., he is sad because the dog was dead, it was sick or had escaped), all of them coherent and suitable with sadness). This trend is observed better in the positive thing than in the negative thing and in the not related condition. This trend can be observed better in the positive condition than in the negative and non-related condition. When the target is non-related, the cause needs less decision time, as we can observe in the triple interaction effect. It is probable that the causal executes of the same form because it forms a part of the base of the comprehension and of the coherence, and is not so submitted to the context. However, the emotion can depend more of the context and of the congruity with the target.

General Discussion

The aim of this study was, on the one hand, to analyze the emotional valence (positive or negative) in the moment in which the emotional inferences are realized (analyzed in experiment 1). For other one, the causal direction was manipulated, given when a circumstance induces to generate or predict an emotion (predictive inference) or when an emotion is induced to the search of a reason (explanatory inference). This objective was of the experiment 2.

In relation with the moment of activation of the emotional inference in experiment 1, we can suggest that the emotional inferences are automatic (*on-line*), as previous

studies suggest (Gernsbacher et al., 1992; Gernsbacher et al, 1998; Gernsbacher and Robertson, 1992; Gygax et al., 2003, 2004, 2007; de Vega et al., 1996). This activation takes place both with the emotional positive inference and with the negative. This confirmation is done in relation to two criteria: a), the emotional inference taken as related target it is generated faster than the non-related word in both cases; and b), the average reaction time, positives (667 ms.) as well as negatives (710 ms.), is of 629 ms.. These times are below the range established by Mckoon and Ratcliff (1992), who suggest that the inferences that are generated regularly during the comprehension only are automatic if they are below 750 ms.

As for the influence of the emotional valence, results show a clear difference about the positive valence; the emotional positive inference generates significantly faster than the negative. In addition, results show that the positive valence affects also to the processing of the history, being faster when the emotional context is positive, and independently of the condition. This observation arises on comparing the related target of a positive condition (e.g., *happy*) with other one non-related (e.g., *garden*) or related to a negative condition (e.g., *sad*) with its non-related one (e.g., *tank*), showing the same activation pattern in the non-related. Thus, when the context has a positive valence, the response to the target is always faster. This proves the weight of the factor of the valence, which not only affects the emotional target, but also to the context (positive or negative). In this case, we can observe a

José A. León et al.

strong asymmetric trend of the positive valence, as previous studies show (e.g., Kuchinke et al., 2005).

However, in spite of previous studies confirm this asymmetry effect of the positive valence (Gygax et al., 2003, 2004, 2007), does not exist a unanimous agreement about a possible theoretical explanation on why this effect takes place. The existing information in comprehension research of histories and emotional inferences turns out to be very limited to give a response on why such a asymmetry takes place in the affective valence. Nevertheless, from other fields related like neuropsychology, where there exists a major diversity of studies (visual, verbal, mixed stimuli, histories, etc.), they also suggest that the activation of the valence is asymmetric, being the positive activation faster than the negative (Baumeister et al., 2001). From these other lines of research they offer different proposals to explain this asymmetry.

One of these proposals suggests the existence of different levels of processing (as Baumeister et al., 2001). Baumeister and colleagues assume that the positive or negative not only concerns the efficiency of the cognitive processes, but also to the way in which the information is processed: the negative thing favors a more systematic, complex and detailed processing, which needs major cognitive effort; and on the contrary, the positive thing tends to promote a way of more schematic, superficial and rapid processing (e.g., Aguado, 2005).

A second line of research proposes that the different cerebral areas dedicated to activate and process each of these types of valence (negative and positive information) could be organized in a different way in the memory (the positive one can be better interconnected in the emotional cognitive system that the negative information), facilitating its recovery (e.g., Isen, 1985; Kuchinke, Jacobos,

Grubich et al, 2005). Other results provided by Kuchinke et al. (2005), using fMRI (Functional Magnetic Resonance Imaging), reveal a great activation in regions associated with the emotional explicit evaluation and recovery of the emotional memory, as well as the semantic recovery. Hereby, they conclude that the semantic processing (words) of the emotional valence affects both in the behavior and in the functional information of neuroimaging. A third proposal attributes the asymmetry to a hemispherical asymmetry, where the right hemisphere shows superiority with regard to the left hemisphere, both for the recognition of the emotional information and for the regulation of the state of mind and of the emotions (Muddy and Grandson, 2001). In other words, there are systems in the left hemisphere related to the positive emotions, whereas his counterparts of the right hemisphere are relating to negative emotion (e.g., Ehrlichman, 1987).

Finally, and in relation to the causal directionality of the inference (explanatory vs. predictive) results from the second experiment demonstrate that the causality is also a basic component of the emotion and that it is generated very fast in an independent way to its direction (cause - emotion, predictive, as also emotion - cause, explanatory). In other words, the causal direction is equally strong when we look for the emotion or the cause that produces it. It is so important to look for the reasons that explain why an emotion happens, like the anticipation or prediction of the emotional reaction of the character in a given history or situation.

Referencias

Aguado, L. (2005). *Emoción, afecto y motivación*. Madrid: Alianza.

Angosto, A., Sánchez, P., Álvarez, M., Cuevas, I., & León, J. A. (2013). Evidence for Top-Down Processing in Reading Comprehension of Children. *Psicología Educativa, 19*, 83-88.

Barroso, J. & Nieto, A. (2001). Estudio de la asimetría cerebral con sujetos necrológicamente normales: procedimientos visuales. *Revista de Neurología, 32*, 382-386.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology, 5*, 323-370.

Cevasco, J., & van den Broek, P. (2013). Studies on the establishment of connections among spoken statements: what can they contribute to the promotion of students' construction of a coherent discourse representation? *Psicología Educativa, 19,* 67-74.

Black, J. B., & Bower, G. H. (1980). Story understanding as problem-solving. *Poetics, 9(1)*, 223-250

Coté, N., Goldman, S. R., & Saul, E. U. (1998). Students making sense of informational text: Relations between processing and representation. *Discourse Processes, 25*, 1-53.

Dávalos, T.&León, J. A. (2013). Inferencias emocionales durante la comprensión lectora. Un estudio sobre el efecto de la valencia mediante una tarea de decisión léxica. *Uaricha Revista de Psicología, 10*, 111-121.

de Vega, M., León, I. Díaz, J. M. (1996). The representation of changing emotions in reading comprehension. *Cognition and Emotion, 10*, 303-321.

Ehrlichman, H. (1987). Hemispheric asymmetry and positive-negative effect. In D. Ottoson (Ed.), *Duality and Unity of the Brain*. Hampshire, UK: Macmillam.

Escudero, I.,& León, J. A. (2007). Procesos inferenciales en la comprensión del discurso escrito: Influencia de la estructura del texto en los procesos de comprensión. *Revista Signos, 40*, 311-336.

Fincher-Kiefer, R. (1996). Encoding differences between bridging and predictive inferences. *Discourse Processes, 22*, 225–246.

Forster, K, & Forster, J. (2003) DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, 35*, 116–124.

Garton, A. F. & Pratt, C. (2004). Reading Stories. In T. Nunes P. Bryant (Eds.), *Handbook of Children's Literacy* (pp. 213-228). Dordrecht: Kluwer Academic Publishers.

Gernsbacher, M. A., Goldsmith, H. H., & Roberston, R. R. W. (1992). Do readers mentally represent character´s emotional states? *Cognition and Emotion, 6,* 89-111.

Gernsbacher, M. A., Hallada, B. M., Robertson, R. R. W. (1998). How automatically do readers infer fictional characters´ emotional states? *Scientific Studies of Reading, 2,* 271-300.

Gernsbacher, M. A. & Robertson, R. R. W. (1992). Knowledge activation versus sentence mapping when representation fictional characters´ emotional states. *Language and Cognitive Processes, 7,* 353-371.

Graesser, A. C. (1981). *Prose comprehension beyond the world.* New York: Springer-Verlag.

Graesser, A. C., & Bertus, L. B. (1998). The construction of causal inferences while reading expository texts on science and technology. *Scientific Studies of Reading, 2,* 247–269.

Graesser, A. C., y Clark, L. F. (1985). *Structures and procedures of implicit knowledge.* Norwood, NJ: Ablex Publishing Company.

Graesser, A. C., Haberlandt, K., & Koizumi, D. (1987). How is reading time influenced by knowledge-based inferences and world knowledge. *Executive control processes in reading,* 217-251.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 10,* 371–395.

Gygax, P., Garnham, A., & Oakhill, J. (2004). Inferring characters´ emotional states: can readers infer specific emotion? *Language and Cognitive Processes, 19,* 613-639.

Gygax, P., Oakhill, J., & Garnham, A. (2003). The representation of characters´ emotional responses: Do readers infer specific emotion? *Cognition and Emotion, 17,* 413-428.

Gygax, P., Tapiero, I., & Carruzzo, E. (2007). Emotional inferences during reading comprehension: What evidence can the self-pace reading paradigm provide? *Discourse Processes, 44,* 33-50.

Isen, A. M. (1985). Asymmetry of happiness and sadness in effects on memory informal collage students: comment on Hasher, Rose, Zackes, Sanft, & Doren. *Journal of Experimental Psychology General. 114,* 388-391.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion, 4,* 23-35.

Keil, A., Ihssen, N., & Heim, S. (2006). Early cortical facilitation for emotionally arousing targets during the attentional blink. *BMC Biology, 4,* 23.

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. (2007). Comprehension in preschool and early elementary children: Skill development and strategy interventions. *Reading comprehension strategies: Theories, interventions, and technologies,* 27-45.

Kintsch, W. (2005). An overview of top-down and bottom-up effects in comprehension: The CI perspective. *Discourse Processes, 39,* 125-128.

Komeda, H., Kawasaki, M., Tsunemi, K., & Kusumi, T. (2009). Differences between estimating protagonists' emotions and evaluating readers' emotions in narrative comprehension. *Cognition and Emotion, 23,* 135-151.

Komeda, H. & Kusumi, T. (2006). The effect of a protagonist's emotional shift on situation model construction. *Memory and Cognition, 34,* 1548-1556.

Kuchinke, L., Jacobos, A. M., Grubich, C., L-H. Vo, M., Conrad, M., & Hermann, M. (2005). Incidental effects of emotional va-

lence in single word processing: An fMRI study, *NeuroImage, 28,* 1022-1032.

León, J. A. (Coord.) (2003). *Conocimiento y Discurso. Claves para inferir y comprender.* Madrid: Pirámide.

León, J. A. (2009). Neuroimagen de los procesos de comprensión en la lectura y el lenguaje. *Psicología Educativa, 15,* 61-71.

León, J. A. & Peñalba, G. (2002). Understanding causality and temporal sequence in scientific discourse. In J. C. Otero, J. A. León & A. C Graesser (Eds.), *The Psychology of the scientific text* (pp. 155-178). Mahwah, Nueva Jersey: Lawrence Erlbaum Associates.

León, J. A. & Pérez, O. (2001). The influence of prior knowledge on the time course of clinical diagnosis inferences: A comparison of experts and novices. *Discourse Processes, 31,* 187-213

Liu, J. H., Karasawa, K., & Weiner, B. (1992). Inferences about the causes of positive and negative emotions. *Society for Personality and Social Psychology, Inc., 18,* 603-615.

Lorch Jr, R. F., Lemarié, J., & Chen, H. T. (2013). Signaling topic structure via headings or preview sentences. *Psicología Educativa, 19,* 59-66.

Magliano, J. P., Baggett, W. B., Johnson, B. K., & Graesser, A. C. (1993). The time-course of generating causal antecedent and causal consequence inferences. *Discourse Processes, 16,* 35-53.

McKoon, G.,, & Ratcliff, R. (1992). Inferences during reading. *Psychological Review, 99,* 440–446.

Miall, D. (1989). Beyond the schema given: Affective comprehension of literary narrative. *Cognition and Emotion, 3,* 55-78.

Millis, K. K. & Graesser, A. C. (1994). The time course of constructing knowledge-based inferences for scientific texts. *Journal of Memory and Language, 33,* 583–599.

Ohira, H., Winton, W. M., & Oyama, M. (1997). Effects of stimulus valence on recognition memory and endogenous eyeblinks: Further evidence for positive-negative asymmetry. *Personality and Social Psychology Bulletin, 24,* 986-993.

Potts, G. R., Keenan, J. M., & Golding, J. M. (1988). Assessing the ocurrence of elaborative inference: Lexical decision versus naming. *Journal of Memory and Language, 27,* 399-415.

Pratto, F. & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61,* 380-391.

Rapp, D. N. & Gerring, R. G. (2002). Readers´ reality-driven and plot-driven analyses in narrative comprehension. *Memory and Cognition, 30,* 779-788.

Robinson-Riegler, G. L. & Winton, W. M. (1996). The role of conscious recollection in recognition of affective material: Evidence for positive-negative asymmetry. *Journal of General Psychology, 123,* 93-104.

Singer, M. (1994). Discourse inference processes. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 1–31). San Diego, CA: Academic.

Singer, M., Halldorson, M., Lear, J. C., & Andrusiak, P. (1992). Validation of causal bridging inferences in discourse understanding. *Journal of Memory and Language, 31,* 507-524.

Singer, M.,, & León, J.A. (2007): Psychological studies of higher language processes: Behavioral and empirical approaches. In F. Schmalhofer, & C. A. Perfetti (Eds.), *Higher level language processes in the brain: Inference and Comprehension processes,* (pp. 19-35). Mahwah, Nueva Jersey: Lawrence Erlbaum.

Taylor, S.E. (1991). Asymmetrical effect of positive and negative events: The mobilization-minimization hypothesis. *Psychological Bulletin, 110,* 67-85.

Trabasso, T., & Magliano, J. P. (1996). Conscious understanding during text comprehension. *Discourse Processes*, *21,* 255-287.

van den Broek, P. (1990a). The causal inference maker: Towards a process model of inference generation in text comprehension. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 423–445). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

van den Broek, P. (1990b). Causal inferences and the comprehension of narrative text. In A. C. Graesser & G. H. Bower (Eds.), *Inferences and text comprehension* (pp. 175–194). San Diego, CA: Academic.