

Trends in the study of implicit alcohol related cognition

María Ayelén Biscarra¹, Karina Conde² y Mariana Cremonte³

Universidad Nacional de Mar del Plata, Consejo Nacional de Investigaciones Científicas y Técnicas

According to the dual process model, the interaction between explicit (controlled) and implicit (automatic) cognitions would allow the understanding of irrational actions like addictive behaviors. This model has gained great popularity among addiction researchers, leading to an exponential growth in publications on implicit alcohol related cognition (IAC). Hence, the goal of this article is to identify trends in the study of IAC by means of a bibliometric and content analysis of the empirical studies published up to May, 2013. Throughout this paper, the studied topics of IAC were characterized, the most prolific countries, authors and journals were recognized, the most cited publications were detected and the most employed methods were identified.

Key words: implicit cognition, alcohol, review article, bibliometric analysis, content analysis.

Tendencias en el estudio de la cognición implícita relacionada con el alcohol

De acuerdo al modelo del doble procesamiento, la interacción entre cogniciones explícitas (controladas) e implícitas (automáticas) permitiría entender acciones irracionales, tales como los comportamientos adictivos. Este modelo ha ganado mucha popularidad entre quienes investigan el consumo de sustancias, produciéndose un crecimiento exponencial de las publicaciones sobre Cogniciones Implícitas hacia el Alcohol (CIA). Por ello, el objetivo de este artículo es describir las tendencias en el estudio de la CIA mediante un análisis bibliométrico y de contenido de los estudios empíricos publicados hasta mayo del 2013. A lo largo de este trabajo se caracterizan las temáticas de las CIA encontradas y se identifican los países, autores y revistas más productivas, las publicaciones más citadas y los métodos más utilizados.

Palabras clave: cognición implícita, alcohol, artículo de revisión, análisis bibliométrico, análisis de contenido.

¹ Licenciada en Psicología. Becaria doctoral de CONICET. Dirección postal: Funes 3250, Cuerpo V Nivel III, Mar del Plata, CP 7600. Contacto: ayelen.biscarra@conicet.gov.ar

² Magíster en Investigación e Innovación en Salud, Cuidados y Calidad de Vida. Becaria doctoral de CONICET. Dirección postal: Funes 3250, Cuerpo V Nivel III, Mar del Plata, CP 7600. Contacto: kconde@mdp.edu.ar

³ Licenciada en Psicología. Investigadora Adjunta en CONICET. Profesora titular en UNMDP. Directora del grupo de investigación Sustancias Psicoactivas y Lesiones por Causa Externa de la UNMDP. Dirección postal: Funes 3250, Cuerpo V Nivel III, Mar del Plata, CP 7600. Contacto: marianacremonte@conicet.gov.ar



Tendências no estudo da cognição implícita relacionada com o álcool

De acordo com o modelo de processamento dual, a interação entre cognições explícitas (controladas) e implícitas (automáticas) audaria as ações irracionais, tais como os comportamentos aditivos. Este modelo ganhou muita popularidade entre os pesquisadores do consumo de substâncias, produzindo um crescimento exponencial de as publicações sobre cognições implícitas relacionadas com o álcool (CIA). Portanto, o objetivo deste artigo é descrever as tendências no estudo da CIA através de um análise bibliométrico e de conteúdo de estudos empíricos publicados até maio de 2013. Ao longo deste artigo são caracterizados os temas da CIA encontrados e são identificados países, autores e revistas mais produtivos, as publicações mais citadas e os métodos mais utilizados.

Palavras-chave: cognição implícita, álcool, artigo de revisão, análise bibliométrico, análise de conteúdo.

Traditionally, substance use decision-making has been explained by approaches that emphasize the rationality of the person and consider that individuals evaluate the cost-benefit impact of every option before undertaking an action. However, as Wiers & de Jong (2006) postulate, a central paradox of addiction is that addicted people continue consuming despite knowing the associated risks. In order to explain these irrational behaviors, during the 70s and 80s, several new theories proposed the existence of two processes underlying behavior: an explicit and controlled process and an implicit and automatic process (Chaiken, 1980; Devine, 1989; Fazio, Sanbonmatsu, Powell & Kardes, 1986; Wason & Evans, 1975). The former acts in a similar way to traditional decision-making approaches: allows for rational, conscious, controllable and rule-based evaluations. The latter is closely tied to intuition and affect, which are automatic, faster, less conscious, less controllable assessments and also more difficult to adjust to expectations and social pressure (Sloman, 1996). Altogether, these theories are known as the Dual Process Model (DPM).

The interesting thing about this model is its suggestion that although the two processes interact to give rise to behavior (Gawronski & Payne, 2010), sometimes a conflict between them may occur, such that the explicit process guides to an action (stop drinking) while the implicit process suggests another (continue drinking). In this cases, the predominance of one or other process on behavior will depend on several factors, including: the cognitive effort required by the behavior and its degree of habituation (Conner, Perugini, O’Gorman, Ayres & Prestwich, 2007), the level of motivation or opportunity that the subject has to make a thoughtful deliberation (Fazio, 1990), the ability of self-regulation and the cognitive resources (Friese, Bargas-Avila, Hofmann & Wiers, 2010), the age (Krank & Goldstein, 2006) and the development of the frontal lobe (Goldberg & Podell, 2000).

Since its formulation, DPM has gained great popularity among researchers of substance consumption, leading to an exponential growth in publications on implicit alcohol related cognition (IAC). Several dimensions of the IAC have been studied, such as alcohol attentional bias and implicit alcohol associations stored in semantic memory (e.g. associations between alcohol and: positive and negative attributes, arousal and sedation states, approach and avoidance concepts, etc.). Different indirect methods to assess IAC have been used, such as reaction time tasks (e.g. Implicit Association Test, Extrinsic Affective Simon Task), priming tasks (e.g. Affective Priming Paradigm, Affect Misattribution Procedure) and word association tasks (e.g. Word Association Test, Outcome Association Test) (Bischarra, Conde, Cremonte & Ledesma, 2016). It has been suggested that the onset of alcohol would depend on the explicit process while the implicit process would play a more important role in the continued use (Wiers & Stacy 2006). It has been found that IAC predicts alcohol related behavior (Lindgren, Foster, Westgate & Neighbors, 2013) and several procedures to modify IAC have been developed. Among them, the Go/No-go procedure (Houben, Nederkoorn, Wiers & Jansen, 2011), the evaluative conditioning (Houben, Havermans & Wiers, 2010), the Alcohol Approach Avoidance Task – AAT (Wiers, Rinck, Kordts, Houben & Strack, 2010), the Alcohol Attention-Control Training Program (Fadardi & Cox, 2009), the Motivational Interview (Miller & Rollnick, 2002) and the Expectancy Challenge (Wiers, Van De Luitgaarden, Van Den Wildenberg & Smulders, 2005).

Given that the number and variety of publications in the area is overwhelming, the purpose of this article is to review the scientific production on the topic by means of a bibliometric and content analysis of the empirical studies published up to May, 2013. Although there are interesting review papers about IAC, they are confined to a specific aspect of IAC, such as the indirect methods to assess IAC (Reich, Below & Goldman, 2010, Wiers & de Jong, 2006), the relationship between IAC and behavior (Rooke, Hine & Thorsteinsson, 2008), or the ways to modify IAC (Wiers, de Jong, Havermans & Jelicic, 2004). However, the present article aims to provide a global vision of the investigations about

IAC. A synthesis such as this could contribute to inform about a scarcely developed area of research in Latin America, which has been growing exponentially in other latitudes with interesting results. Specifically, this work is intended to show how research on the issue evolved through time; identify the most productive countries, authors and journals of the area; detect the most employed methods, the most cited publications; characterize the studied topics, and summarize the main results.

Method

We performed a search for empiric articles during April-May 2013 in international (Scopus, PsycInfo, Pubmed, Cinhal, Cochrane Central Register of Controlled Trials and DOAJ) and regional (Dialnet, Lilacs and Scielo) databases. Additionally, a simple search was conducted using Google Scholar. Search strategy was: 1) Implicit AND (cognition OR attitude OR association) AND (alcohol OR drinking). Failure to find results led to the inclusion of general words such as: 1) implicit AND alcohol; 2) (cognition OR attitude) AND alcohol. The search was performed in both English and Spanish, and limited to title abstract and key words (or subject), except when no articles were found. No time limit was established. No articles were found in DOAJ, Dialnet and Scielo.

Duplicated articles, those not pertaining to the topic, book chapters, theses, congress presentations, reviews and meta-analysis were detected and excluded. One article with insufficient information was discarded. Ninety-nine articles were included and divided by three researchers who extracted and coded the following data in order to realize bibliometric analyses: publication year, title, number of citations with Google Scholar, authors, geographic location, source, and method of assessment used. To perform content analysis one of the researchers identified recurrent objectives through the articles and classified them in several thematic categories. If in doubt with the classification of an article, the collaboration of other research was requested.

Results

Bibliometric assessments

Scientific production on IAC began in 1995 and increased over time (Figure 1).

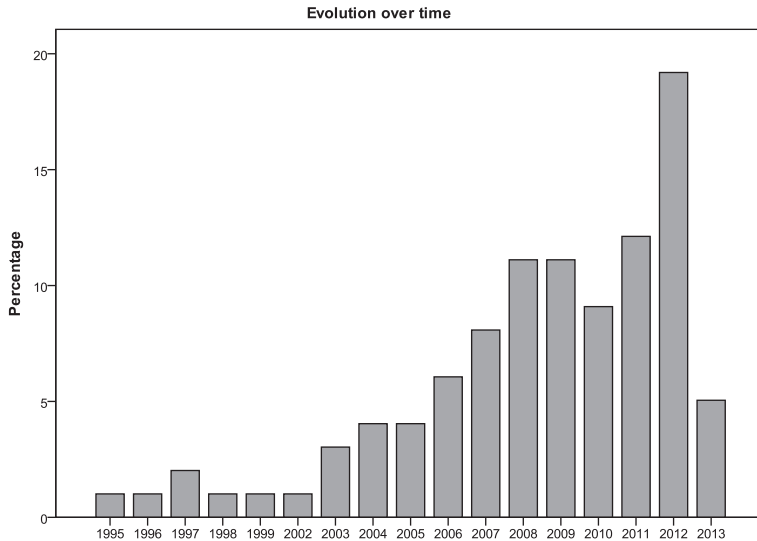


Figure 1. Evolution of articles published on implicit alcohol related cognition over time

Regarding scientific production by country, the most productive country was United States (43%), followed by Netherlands (30%) and, to a lesser extent, by Canada, United Kingdom, Australia, Switzerland, Belgium, Germany and Poland. Those two first countries accounted for the great majority of publications on the topic. On the other hand, there was a notable absence of literature from other European, Asian and Latin-American countries. Regarding authors, a total of 189 were registered. Most of them authored three articles or less, while five authors generated over 20% of the production on the topic (Table 1).

Table 1*Productivity of the authors who investigate implicit alcohol related cognitions*

Authors	Number of articles	Percentage
Wiers, R. W.	31	9.2
Houben, K.	15	4.5
Stacy, A. W.	10	3.0
Ostafin, B. D.	8	2.4
Ames, S. L.	7	2.1
Lindgren, K. P.	6	1.8
Sussman, S.	6	1.8
McCarthy, D. M.	5	1.5
Palfai, T. P.	5	1.5
Thush, C.	5	1.5
Engels, R. C. M. E.	4	1.2
Grenard, J. L.	4	1.2
Kelly, A. B.	4	1.2
Neighbors, C.	4	1.2
Others	≤ 3	66.1
Total	-	100

The journals containing the higher number of publications on the topic were Addictive Behaviors (20%), Psychology of Addictive Behaviors (15%), Addiction (5%), and Alcoholism: clinical and experimental research (5%) and Drug and Alcohol Dependence (5%). The most frequently used method to assess IAC was the Implicit Association Test (Table 2), which was employed in slightly over half of the articles.

Table 2

Methods employed in studies of implicit alcohol related cognition

Indirect method	Frequency	Percentage
Implicit Association Test	57	50.4
Word association task	14	12.4
Priming Task	8	7.1
Extrinsic Affective Simon Task	6	5.3
Stroop Test	6	5.3
Others	≤ 4	19.5
Total	113 [§]	100.0

Note. [§] Some articles used more than one method.

Table 3 contains the most frequently cited articles.

Table 3

Articles on implicit alcohol related cognition with highest number of citations

Article	No. of citations
Stacy, A.W (1997) Memory activation and expectancy as prospective predictors of alcohol and marijuana use.	294
Wiers, R.W., van Woerden, N., Smulders, F. T. Y. & de Jong, P. J. (2002). Implicit and explicit alcohol-related cognitions in heavy and light drinkers.	273
Wiers, R. W., van de Luitgaarden, J., van Den Wildenberg, E. & Smulders, F. T. Y (2005). Challenging implicit and explicit alcohol-related cognitions in young heavy drinkers.	130
Friese, M., Hofmann, W. & Wänke, M. (2008). When impulses take over: Moderated predictive validity of explicit and implicit attitude measures in predicting food choice and consumption behavior.	127
Roehrich, M. S. & Goldman, M. (1995). Implicit priming of alcohol expectancy memory processes and subsequent drinking behavior.	123

Article	No. of citations
Palfai, T. P. & Ostafin, B. D. (2003). Alcohol-related motivational tendencies in hazardous drinkers: Assessing implicit response tendencies using the modified-IAT.	117
Payne, B. K., Burkley, M. A. & Stokes, M. B. (2008) Why Do Implicit and Explicit Attitude Tests Diverge? The Role of Structural Fit.	112
Jajodia, A. & Earleywine, M. (2003). Measuring alcohol expectancies with the implicit association test.	110
Thush et al. (2008). Interactions between implicit and explicit cognition and working memory capacity in the prediction of alcohol use in at-risk adolescents.	93
Wiers, R. W., Rinck, M., Kordts, R., Houben, K. & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers.	87
De Houwer, J., Crombez, G., Koster, E. H. W. & De Beul, N. (2004). Implicit alcohol-related cognitions in a clinical sample of heavy drinkers.	85
Fardari, J. S. & Cox, W. M (2009). Reversing the sequence: Reducing alcohol consumption by overcoming alcohol attentional bias.	83
Thush, C. & Wiers, R. W (2007). Explicit and implicit alcohol-related cognitions and the prediction of future drinking in adolescents.	78

Content analysis

The 53 % of the articles assessed only IAC, while the rest also evaluated explicit alcohol related cognition (EAC). The great majority (86 %) only analyzed IAC, while a minority (10%) included as well implicit cognition related to other substances, and some (6 %) studied IAC and implicit cognition tied to other behaviors. Almost every article (94 %) assessed only implicit alcohol associations. Nonetheless, a few addressed alcohol attentional bias (4 %), and one studied both IAC dimensions (1 %).

The contents of the reviewed articles may be grouped in the non-exhaustive topics summarized below.

Topic 1: methods of IAC assessment

The IAC are evaluated through indirect methods, characterized by inferring participant's cognition from his performance on a task that requires rapid responses to prevent conscious control of the answers or conform to social expectations. These methods can be classified into: reaction time tasks (e.g. Implicit Association Test, Extrinsic Affective Simon Task), priming tasks (e.g. Affective Priming Paradigm, Affect Misattribution Procedure) and word association tasks (e.g. Word Association Test, Outcome Association Test).

The Implicit Association Test (IAT, Greenwald, McGhee & Schwartz, 1998) is the most widely used method in the evaluation of the IAC. It is a computerized classification task that measures reaction times and assumes the participant take less and makes fewer mistakes when he has to classify together stimuli that are associated implicitly in his memory. There are several versions of this method. In the bipolar Alcohol IAT, the participant has to classify alcohol stimuli and contrast stimuli (e.g. sodas) with positive and negative words (e.g. love and war respectively). If the participant finds it easier to classify together alcohol stimuli with positive words, it follows that the concepts alcohol and positive are implicitly associated in his memory and that he has a positive implicit attitude towards alcohol. In the Alcohol ST-IAT, alcohol stimuli and neutral words (e.g. average, habitual, ordinary, etc) must be classified with positive and negative words. In the Alcohol Unipolar IAT, stimuli belonging to two categories of contrast (alcohol vs sodas) must be classified with positive and neutral words. In the Alcohol Unipolar ST-IAT, alcohol stimuli and neutral words must be classified with positive and neutral words (Alcohol Unipolar Positive ST IAT) or with negative and neutral words (Alcohol Unipolar Negative ST IAT). There are also various kinds of Alcohol IAT according to the content of the implicit association assessed: alcohol with positive and negative attributes, alcohol with arousal and sedation concepts, alcohol with approach and avoidance tendencies, alcohol with self and not self stimuli, etc. Finally, combinations can occur between all

of these Alcohol IAT versions, like the Alcohol Approach IAT (Palfai & Ostafin, 2003), a bipolar IAT composed by two contrast category (alcohol vs sodas) and two type of attributes (approach vs avoid). For a more detailed description of the IAT and other indirect methods see Biscarra, et al. (2016).

Many of the analyzed articles evaluated the validity of the methods of IAC assessment and found that: the IAT, the Extrinsic Affective Simon Task (EAST; De Houwer, 2003), the Affect Misattribution Procedure (AMP; Payne, Cheng, Govorun & Stewart, 2005), the Affective Priming Paradigm (APP; Fazio et al., 1986), and the Word Association Test (Stacy, Leigh & Weingardt, 1994) were valid methods to assess IAC (Gray, LaPlante, Bannon, Ambady & Shaffer, 2011; Houben, Rothermund & Wiers, 2009; Lindgren, Westgate, Kilmer, Kaysen & Teachman, 2012; Lindgren, Hendershot, Neighbors, Blayney & Otto, 2011; Ostafin & Palfai, 2006; Payne, Govorun & Arbuckle, 2008).

Some articles compared several versions of the IAT. Houben, Nosek & Wiers (2010) compared bipolar, unipolar positive and unipolar negative versions of the Alcohol-related affective IAT (whose attributes consisted of positive and negative affective states related to alcohol consumption such as happy or sad) and the General affective IAT (composed with general positive and negative attributes such as war or peace) and found that bipolar Alcohol-related affective IAT outperformed the other versions regarding its relation to the explicit measures and alcohol consumption. Lindgren et al. (2013) compared the Drinking Identity IAT, the Alcohol Approach IAT, the Alcohol Cope IAT, the Alcohol Excitement IAT and the Stress Drinking IAT and found that the Drinking Identity IAT exhibit the highest internal consistency and test re test reliability and was the strongest predictor of alcohol consumption, related problems, and cravings.

Certain articles empirically examined the most common criticisms to the IAT (see Wiers & de Jong, 2006), finding that: a) the figure-background asymmetry would not suffice to explain IAT results (Houben & Wiers, 2006a, 2006b); b) the IAT results could revealed both, the general opinion of members of the society involving an object

and a personal attitude towards such object (Houben & Wiers, 2007a, b); and c) the IAT results were influenced by the category labels and the contrast category only in the unipolar negative IAT, not in the unipolar positive IAT, neither in the arousal IAT, nor in the sedation IAT (Houben & Wiers, 2006a).

Another articles compared different indirect methods: the Word Association Test, the IAT, the EAST, the AMP and the APP. They found that although all of them predicted alcohol use, the Word Association Test and the AMP predicts alcohol use better than the others (Payne, Govorun & Arbuckle, 2008). Some articles analyzed the influence of other factors such as: a) the structures of the indirect and direct methods, detecting higher correlation between the methods when they were similar (Payne, Burkley & Stokes, 2008); b) the social desirability effects, detecting a stronger relationship between such methods among participants with low motivation to hide alcohol consumption (Payne, Burkley & Stokes, 2008); and c) the administration sequence of instruments, finding that participants only presented positive implicit alcohol associations when completing the indirect method before the direct one (Noel & Thomson, 2012).

Finally, an article compared two ways of codifying the answers of a Word Association Test in low and high-risk activities (such as alcohol and marijuana consumption): participants' auto-coding and researchers' coding; and found that the auto-coding improved the prediction of substance consumption (Krank, Schoenfeld & Frigon, 2010). And other article standardized the graphic stimuli (pictures of alcoholic and non-alcoholic drinks) that could be used in implicit tasks to assess cognitive biases in individuals with mild to borderline intellectual disability (Van Duijvenbode, Didden, Bloemsaat & Engels, 2012).

Topic 2: Relationship between IAC and drinking related behavior

Regardless of the methodological procedures employed (not shown), all the articles examining the link between IAC and drinking related behavior, except one (Larsen, Engels, Wiers, Granic & Spijkerman, 2012), found that IAC predicts that behavior.

Moreover, some articles proved that IAC contributes, in particular and beyond the explicit cognition, to predict alcohol consumption (Houben & Wiers, 2007a; Houben & Wiers, 2007b; Houben & Wiers, 2008a; Houben, Rothermund & Wiers, 2009; Houben, Nosek & Wiers, 2010; Wiers et al., 2002; Jajodia & Earleywine, 2003; Stacy, 1997).

Others examined the role of mediating variables between IAC and drinking related behavior and established that the relationship was not affected by demographic variables such as gender or ethnicity (Ames & Stacy, 1998; Stacy, Ames, Sussman & Dent, 1996), but rather by other factors: frequency of alcohol consumption (Kelly, Masterman & Marlatt, 2005), discrepancy between explicit and implicit alcohol associations (Karpen, Jia & Rydell, 2012), emotional state (Wardell, Read, Curtin & Merrill, 2012), COMT and ALDH2 genotypes (Hendershot, Lindgren, Liang & Hutchison, 2012) and executive functions (Burton, Pedersen & McCarthy, 2012; Farris, Ostafin & Palfai, 2010; Ostafin & Palfai, 2012; Friese et al., 2010; Friese, Hofmann & Wänke, 2008; Grenard, Ames, Wiers, Thush, Sussman & Stacy, 2008; Houben & Wiers, 2009a; Ostafin, Marlatt & Greenwald, 2008; Thush & Wiers, 2008). Finally, an article estimated the effect of acute alcohol intake on IAC and asserted that it would not modify IAC (Pedersen, Treloar, Burton & McCarthy, 2011).

Topic 3: IAC among children-youth

Some articles evaluated IAC in children at large, i.e., regardless of whether they already consumed alcohol or not, (O'Connor, Fite, Nowlin & Colder, 2007; Noel & Thomson, 2012) and others articles additionally compared IAC in drinking and abstaining children (Pieters, van der Vorst, Engels & Wiers, 2010; O'Connor, Lopez-Ver-gara & Colder, 2012). They yielded different and even contradictory results, probably due to the indirect method employed (Table 4).

Table 4

Articles examining implicit alcohol related cognition in children

Study	Indirect method	Sample	Results
O'Connor et al. (2007)	Priming task	Children between 6 and 10 years old	The children presented positive implicit associations regarding alcohol use.
Noel & Thomson (2012)	Unipolar negative IAT. Unipolar positive IAT	Children between 8 and 14 years old	The children presented both negative and positive implicit associations regarding alcohol use, according to the sequence of administration of the explicit measure and the implicit measures.
Pieters et al., 2010	Bipolar IAT	Children between 9 and 13 years old	All the children exhibited strong negative implicit alcohol associations, but those who already used alcohol presented stronger negative implicit associations than abstainers did.
O'Connor, Lopez-Vergara & Colder (2012)	Bipolar ST-IAT	Children between 10 and 12 years old	The children presented strong negative implicit alcohol associations. However, concurrently to the automatic activation process of these associations, they initiated a controlled process suppressing the activation of negative associations, which results in positive attitudes towards alcohol. Abstainers presented stronger negative implicit association than drinkers did.

Note: IAT = Implicit Association Test; ST-IAT = Single Target Implicit Association Test

Many articles studied IAC in adolescents. They found that: a) IAC predicted alcohol use (Ames, Sussman, Dent & Stacy, 2005; Rooke & Hine, 2011; Stacy et al. 1996); b) the prediction was stronger in adolescents with worst working memory capacity (Thush et al., 2008); c) adolescents had stronger implicit alcohol associations than adults (Rooke & Hine, 2011); and d) heavy drinkers presented weaker implicit alcohol-approach associations (van Hemel-Ruiter, de Jong & Wiers, 2011). Other article tested positive and negative implicit alcohol associations, and implicit alcohol arousal-sedation associations in two groups of adolescents and found that: a) drinkers belonging to the 15-year-old group displayed positive implicit alcohol association, while the abstainers had negative implicit alcohol association; and b) in the 12-year-old group, male drinkers presented stronger implicit alcohol-arousal associations than abstainers, while female drinkers exhibited weaker implicit alcohol-arousal associations than abstainers (Thush & Wiers, 2007).

Finally, several articles analyzed the relation between parental alcohol consumption and IAC in their children and concluded that parental consumption was related to negative implicit alcohol associations (Pieters et al. 2010) and to implicit alcohol-arousal associations (Belles, Budde, Moesgen & Klein, 2011). Even, parental consumption was positively tied to the number of implicit alcohol associations in their children and this relationship predicted alcohol use in them (van der Vorst et al., 2013).

Topic 4: interventions for IAC

Several articles evaluated different procedures to modify IAC. Some of them found that, regardless of the indirect method used to assess IAC (not shown), the evaluative conditioning (Houben, Havermans & Wiers, 2010), the Approach Avoidance Test (Wiers, et al. 2010; Wiers, Eberl, Rinck, Becker & Lindenmeyer, 2011) and the Alcohol Attention-Control Training Program (Fadardi & Cox, 2009) allowed IAC modification and alcohol use reduction.

However, articles assessing the Go/No go procedure reached different results. On one hand, some of them indicated changes on implicit alcohol associations and diminished consumption (Houben, Havermans, Nederkoorn & Jansen, 2012; Houben et al., 2011). On the other hand, other article found reduction of consumption without changes in implicit alcohol associations (Bowley, Faricy, Hegarty, Johnstone, Smith, Kelly & Rushby, 2013). These articles coincided in the assessed IAC dimensions (positive and negative implicit alcohol associations) as well as the indirect method employed (bipolar IAT). However, they differed in the samples: university students with heavy drinking (Houben et al., 2012; Houben et al., 2011) and with different consumption levels (Bowley et al., 2013).

An article found that Motivational Interview modified IAC and EAC without changing alcohol use (Thush, Wiers, Moerbeek, Ames, Grenard, Sussman & Stacy, 2009). Another found that the Expectancy Challenge reduced implicit alcohol-arousal associations, but that such reduction was obtained only while using the original algorithm IAT scoring method (Wiers, van de Luitgaarden, van den Wildenberg & Smulders, 2005). Other concluded that implicit alcohol-approach associations tempered the effects of brief interventions on hazardous drinking university students; since those with weak implicit alcohol-approach associations assessed with bipolar IAT had higher reductions in consumption than those with strong implicit alcohol-approach associations (Ostafin & Palfai, 2012).

Topic 5: IAC evaluation and drinking patterns

These articles evaluated several IAC dimensions among participants with certain drinking patterns. The ones that considered implicit attitudes (implicit associations between alcohol and positive or negative attributes) and implicit alcohol-arousal associations yielded different results (Table 5).

Table 5*Implicit attitudes and implicit alcohol arousal associations based on drinking patterns*

Study	IAC dimension	Method	Sample	Results
Wiers, et al. (2002)	Implicit attitudes & Implicit arousal	Bipolar IAT	Heavy and light drinkers	Both types of drinkers possess strong negative implicit attitudes towards alcohol, but heavy drinkers associate alcohol to arousal words rather than to sedation words, while light drinkers respond equally fast to arousal and sedation words.
Wiers et al. (2005)	Implicit attitudes & Implicit arousal	Bipolar IAT	Heavy drinkers	Participants expressed strong negative implicit attitudes towards alcohol and strong implicit alcohol arousal associations.
De Houwer et al. (2004)	Implicit attitudes & Implicit arousal	Bipolar IAT	Alcohol-dependent patients undergoing treatment	Participants presented strong negative implicit attitudes towards alcohol and strong implicit alcohol arousal associations.
Kramer & Goldman (2003)	Implicit arousal	Stroop Test	Heavy and light drinkers	Heavy drinkers displayed interference when arousing expectancy words had been primed by an alcohol word, whereas light drinkers displayed interference when sedating expectancy targets had been so primed.

Study	IAC dimension	Method	Sample	Results
Dickson, Gately & Field (2013)	Implicit attitudes	unipolar-IAT	Alcohol dependent patients and social drinkers	Both groups presented positive implicit attitudes towards alcohol, but alcohol dependent patients showed negative implicit attitudes significantly weaker than those from social drinkers.
McPherson & Harris (2013)	Implicit attitudes	Unipolar ST-IAT	Alcohol dependent non-dependent patients	Alcohol dependent patients presented stronger positive implicit attitudes towards alcohol than those from non-dependent patients.
O'Connor & Colder (2009)	Implicit attitudes	Semantic priming tasks	Heavy and light drinkers	Light drinkers presented ambivalent implicit attitudes towards alcohol, while heavy drinkers presented strong positive implicit attitudes towards alcohol.
de Jong, et al. (2007)	Implicit attitudes	Extrinsic Affective Simon Task (EAST)	Heavy and light drinkers	Both groups presented positive implicit attitudes towards soda and ambivalent implicit attitudes towards alcohol.
De Houwer & De Bruycker (2007)	Implicit attitudes	ID-EAST	Heavy and light drinkers	Heavy drinkers presented stronger positive implicit attitudes towards beer than those from light drinkers.

Note: Implicit attitudes = implicit associations between alcohol and positive or negative concepts; Implicit arousal = implicit associations between alcohol and arousal or sedating concepts; IAT = Implicit Association Test; ST-IAT = Single Target Implicit Association Test; EAST = Extrinsic Affective Simon Task; ID-EAST = Identification Extrinsic Affective Simon Task

One article found that individual differences in consumption frequency predicted the probability of answers containing alcohol-related words in a Word Association Task (Stacy, 1997). Another evaluated implicit alcohol approach-avoidance associations with the Stimulus-Response Compatibility Task (SRC; De Houwer, Crombez, Baeyens & Hermans, 2001) in alcohol-dependent patients undergoing treatment and light-drinking controls and found that although these groups did not differ in their implicit associations, individual differences in the amount consumed prior to treatment initiation were strongly linked to the implicit alcohol-approach associations, not to the implicit alcohol-avoidance associations (Barkby, Dickson, Roper & Field, 2012).

Some articles assessed alcohol attentional bias with the Stroop Test (Stroop, 1935), and found that: a) heavy drinkers featured a higher alcohol attentional bias than light drinkers did (Bruce & Jones, 2004); and b) harmful drinkers presented higher alcohol attentional bias than hazardous and social drinkers (Fadardi & Cox, 2009).

Topic 6: Context influence on IAC

It was found that in alcohol related contexts, such as a bar laboratory (Lau-Barraco & Dunn, 2009) or reading a vignette about a date where alcohol is present (Lindgren, Neighbors, Ostafin, Mullins & George, 2009), IAC tended to increase. However, Coronges, Stacy & Valente (2011) study concluded that in a group of high school friends, social influence had a greater impact on implicit associations than on behavior. Moreover, Goodall & Slater (2010) found that advertisement had an indirect influence on the willingness to get involved in impulsive and reckless behaviors (such as driving under the influence), automatically activating positive implicit alcohol associations. And they argued that advertisements had a greater impact on implicit than on explicit alcohol associations.

However, while exploring the emotional context influence on IAC, there are studies that assessed the relationship between the emotional context and IAC without manipulating the emotional state

of the participants, while others estimated the effect of the induction of certain emotional states on IAC. In addition, both groups of studies evaluated the effect of mediating variables (drinking motives, alcohol-related expectancies, psychological distress and benzodiazepines use). The first group found that: a) negative affective cues eased the activation of IAC in coping motives and problem drinkers and this activation predicted alcohol consumption (Campos-Melady & Smith, 2012; Zack, Toneatto & MacLeod, 1999); b) high doses of benzodiazepines reduced that activation while low doses eased it (Zack, Poulos & Woodford, 2006); c) there was a strong relationship between depressive symptoms and positive implicit alcohol associations in coping motives drinkers (Ralston & Palfai, 2012); and d) coping motives drinkers present higher alcohol attentional bias than no coping motives drinkers (Forestell, Dickter & Young, 2012). The second group of articles found that: a) an induction of a negative emotional state predicted IAC in high risk drinkers (Kelly & Masterman, 2008), in CM drinkers (Ostafin & Brooks, 2011), in individuals with high tendency to act impulsively during negative emotional states (Treloar & McCarthy, 2012) and in individuals with weak implicit expectancies that alcohol generates negative emotions (Kelly, Masterman & Young, 2011); b) an induction of an anxiety emotional state predicted IAC in coping-anxiety motive drinkers; and c) an induction of a positive emotional state predicted IAC in low risk drinkers (Kelly & Masterman, 2008) and enhancement motive drinkers (Birch, Stewart, Wiers, Klein, MacLean & Berish, 2008; Grant, Stewart & Birch, 2007).

Finally, one article found that the emotional state was a moderator in the relationship between implicit alcohol related expectancies and alcohol consumption (Wardell et al., 2012), while other did not support its hypothesis that the emotional state acted as a moderator of the relationship between drinking restraint and implicit alcohol approach-avoidance associations (Cohn, Cameron, Udo, Hagman, Mitchel, Bamm & Ehlke, 2012).

Topic 7: others

This section grouped the less studied topics related to IAC: differences between implicit alcohol associations according to ethnic group (Pedersen et al., 2011); implicit alcohol associations in people with gambling problems (Zack, Stewart, Klein, Loba & Fragopoulos, 2005); relationship between IAC and aggression (Brown, Lipka, Coyne, Qualter, Barlow & Taylor, 2011; Wiers, Beckers, Houben & Hofmann, 2009); influence of genetic factors on IAC (Hendershot et al., 2012; Wiers, Rinck, Dictus & van den Wildenberg, 2009); effects of IAC on social disinhibition (Freeman, Friedman, Bartholow & Wulfert, 2010); influence of implicit alcohol-related expectancies on self-perception (Hicks, Schlegel, Friedman & McCarthy, 2009); role of self-reference in the relationship between persuasive messages and implicit and explicit attitudes related to stigmatized behaviors such as alcohol consumption (Maliszewski, 2004); and relationship between heart rate acceleration induced by alcohol and IAC in heavy drinkers (Van den Wildenberg, Beckers, van Lambaart, Conrod & Wiers, 2006).

Discussion

Trends on the scientific output regarding IAC have been identified by means of a bibliometric and content analysis. For this end, a wide variety of international and regional databases were consulted. Despite some interesting previous review papers about IAC, they are focused on an aspect of IAC, while the present article aims to provide a global overview of the investigated topics on IAC, considering that a synthesis like this would contribute to report about a research area that has grown overwhelmingly in some countries but has been poorly developed in Latin America.

In fact, the bibliometric analysis showed that the most productive countries in IAC were United States and Netherlands. Surprisingly, there was a notable lack of studies from many European, Asian or Latin-American countries, probably signaling not only a lower level

of development of scientific research but also research traditions and interests. Furthermore, a group of a few authors was identified as the most prolific. Their relevance goes beyond the number of empiric articles they published. Their vast experience is reflected not only in the years devoted to the field and their high number of citations (the case of members like Stacy, A. W.; Sussman, S.; Ames, S. L.; Wiers, R. W.; and Palfai, T. P.), but also in their theoretical publications (Ostafin & Palfai, 2006; Stacy, Ames & Leigh, 2004; Stacy, Ames, Wiers & Krank, 2009; Thush & Wiers, 2008; Wiers, Bartholow, van den Wildenberg, Thush, Engels, Sher, Stacy, 2007; Wiers, de Jong, Havermans & Jelicic, 2004; Wiers & de Jong, 2006) which serve as reference for younger researchers. Furthermore, there is a large number of works intended as internal cooperation for this group, which evidences the proliferation of an extensive scientific exchange within the area.

As expected, most of the publications were registered in journals specialized in addictions, reflecting the importance attached to implicit processes in addictive behaviors research.

The methods of IAC assessment and the relationship between IAC and drinking related behavior were, by far, the most studied topic. The most employed method was IAT and a lot of the reviewed articles studied IAT performance. It constitutes a valid and reliable instrument (Nosek, Greenwald & Banaji, 2007) and is the instrument with more versions developed (see Roefs, Huijding, Smulders, MacLeod, de Jong, Wiers & Jansen, 2011). These versions have apparently overcome some of the flaws attributed to bipolar IAT (e.g., that it is a relative measure, that it assesses society's attitudes, that the results depend on a figure-background asymmetry, etc.) and researchers recommended the unipolar and single target versions to assess objects generating ambivalence, such as alcohol (Wiers & de Jong, 2006). Other examined articles compared different indirect methods. Their results suggest that word association tasks and AMP are the most efficient methods. These findings agree, in part, with the meta-analysis by Rooke, Hine and Thorsteinsson (2008), who found that word association tasks performed better than IAT, priming tasks and EAST did. Finally, some

reviewed articles revealed the importance of considering some methodological biases (e.g. task structure and sequence of administration) and social desirability bias when assessing IAC and EAC.

Concerning the relationship between IAC and DRB, there is considerable empiric evidence demonstrating that IAC predicts and is related to alcohol use, and many articles showed that executive functions moderate that relationship. Regarding the article with contradictory evidence (Larsen et al., 2012), as the authors themselves expressed, their study was undertaken in a semi-natural environment, the participants were aware to being in a university bar, and this could have motivated them to control consumption. Additionally, supporting DPM, the reviewed articles demonstrated that IAC contributes in particular and beyond explicit cognition to alcohol consumption prediction (Wiers, van Woerden, Smulders & de Jong, 2002; Jajodia & Earleywine, 2003; Stacy, 1997), which shows that both types of cognitions are not redundant for the prediction of alcohol related behavior and highlights the importance of assessing both.

On the other hand, the articles that assessed IAC in children revealed different and contradictory results. First, once again, it is important to consider possible methodological biases in the interpretation of results, since it was demonstrated that the evaluation was affected by the sequence of tests administration (Noel & Thomson, 2012) and, the opposite results obtained with different methods would suggest that the evaluation may be affected by the instrument employed as well (see Table 4). Secondly, results would suggest that children may have ambivalent implicit attitudes towards alcohol in the same way they have ambivalent explicit attitudes (Cameron, Stritzke & Durkin, 2003). In fact, O'Connor et al. (2012) postulated that among children negative implicit alcohol associations are activated along with processes that allow overcoming this automatic activation, translating them into positive implicit alcohol associations. And according to Pieters et al. (2010) children may have ambivalent implicit attitudes; however when the indirect method used assessed simultaneously both dimensions of the attitude, the negative implicit one could be stronger

than the positive, thus masking it. Therefore, as already pointed out, some authors recommended to assess both attitude dimensions individually. Thirdly, the conclusions drawn by Noel and Thomson (2012), O'Connor et al. (2012), and the results reviewed here from the group of articles that evaluated the methods of IAC assessment, stressed, on balance, the importance of cognitive resources in IAC, since the possibility of performing a previous deliberation process regarding alcohol seems to diminish the power of positive implicit alcohol associations.

Among adolescents, against all expectations, one article found that heavy drinkers have weaker implicit alcohol-approach associations than light drinkers did (van Hemel-Ruiter et al., 2011). This result differed from the results obtained with late-adolescents and adults, who presented strong implicit alcohol-approach associations (Field, Mogg & Bradley, 2005; Field, Kiernan, Eastwood & Child, 2008; Palfai & Ostafin, 2003; Wiers et al., 2009). Van Hemel-Ruiter et al. (2011) ascribed these differences to the fact that younger participants had a shorter alcohol use record, insufficient to produce strong implicit alcohol-approach associations. They also clarified that the weak implicit alcohol-approach associations detected among heavy drinkers could be due to a negative conditioning to alcohol. The authors argued that probably heavy drinkers had been punished for their consumption, thus knowing that alcohol use was disapproved by adults. Therefore, assessing them at school may have activated negative implicit alcohol associations (e.g. associations related to negative reactions of the teachers regarding students' alcohol consumption) and this activation could have prompted implicit alcohol-avoidance associations.

Regarding parental alcohol consumption, the found articles demonstrated that it was connected with negative implicit alcohol associations (Pieters et al., 2010) and with implicit alcohol-arousal associations (Belles et al., 2011) in their children. Perhaps, as suggested by Pieters et al. (2010), that's because children could have noticed the consequences alcohol has in their parents (excitement, euphoria, bad mood, quarrels, etc).

Since, as noted, IAC predicts alcohol use, researchers designed several procedures to modify IAC, which eventually lead to changes

in alcohol use. Concerning these interventions, the reviewed articles demonstrated that the evaluative conditioning, the Alcohol Approach Avoidance Task, the Alcohol Attention Control Training Program and the Motivational Interview of Miller and Rollnick (2002) are suitable procedures to modify IAC. Also, even though the Expectancy Challenge and the Go/No-go procedure constitute promising procedures for IAC modification, further studies should be conducted, since, as yet, results have been either contradictory (Houben et al., 2012; Houben et al., 2011) or dependent on methodological issues, such as on the algorithm used for IAT scoring (Wiers et al., 2005). Finally, one article (Ostafin & Palfai, 2012) underlined the importance of considering the possible effects of IAC on brief interventions aimed to reduce alcohol consumption.

Regarding the IAC evaluation among participants with certain drinking patterns, first, the results of the articles dealing with implicit attitudes towards alcohol differ according to the indirect method employed. So, using relative measures, such as bipolar IAT, negative implicit alcohol associations in light drinkers, heavy drinkers and alcohol dependents were found; while using absolute versions of IAT and other indirect methods, positive and ambivalent implicit attitudes were found in heavy drinkers, ambivalent implicit attitudes in light drinkers and positive implicit attitudes in alcohol dependents (see Table 5). Maybe, the studies using absolute methods are more valid, since the results found with relative measures may reflect positive soda associations rather than negative alcohol associations (de Jong, Wiers, van de Braak & Huijding, 2007). Secondly, differences were found neither in the implicit attitudes towards alcohol (Wiers et al., 2002; Wiers et al. 2005; De Houwer et al. 2004; de Jong et al., 2007) nor in the implicit associations between alcohol and approach/avoidance words (Barkby et al. 2012) based on drinking patterns. However, differences were detected in implicit associations between alcohol and arousal/sedation concepts (Wiers et al. 2002; Wiers et al., 2005; De Houwer et al. 2004; Kramer & Goldman, 2003) and in the alcohol attentional bias (Bruce & Jones, 2004; Fadardi & Cox, 2009) among different

types of drinkers. Therefore, it was suggested that other dimensions of IAC, aside from the implicit attitudes, should be analyzed when assessing IAC (Wiers & de Jong, 2006). Thirdly, results from other articles suggested that higher consumption levels led to higher attentional bias (Bruce & Jones, 2004; Fadardi & Cox, 2009).

Regarding context influences on IAC, first, some articles showed that implicit alcohol associations increased in alcohol related contexts. Taking into account that other reviewed articles demonstrated that IAC predicts drinking related behavior, it is feasible that people within alcohol-related contexts are more prone to consume such substance given the IAC activation generated in such contexts. Secondly, one article found that social context affects IAC, and that it even has a greater impact on IAC than on behavior. Besides, other article suggested that it is possible that some advertisements promote positive implicit alcohol associations more easily than positive explicit ones. Thirdly, the reviewed articles revealed that certain emotional states ease IAC activation, with individual differences (such as the presence or absence of psychological distress, the tendency to impulsively respond to certain emotions, internal reasons leading to alcohol consumption and the individuals' expectancies on the effects of alcohol use) moderating the relationship between the emotional state and IAC. The evaluation of internal motivation for alcohol consumption as a mediating variable between emotional state and IAC revealed that IAC activation in enhancement motive drinkers is stronger when they experiment positive emotional states, though such activation in coping motive drinkers is stronger when they suffer negative emotional states (Grant et al., 2007). Furthermore, one article found that the emotional state moderated the relationship between the implicit alcohol-related expectancies and consumption. So, given that IAC predicts drinking related behavior, that the emotional state moderates the relationship between IAC and consumption, and that alcohol relapse is associated to positive and negative emotional states (Connors, Longabaugh & Miller, 1996), the results presented highlight the need to pay attention to the emotional state of those in recovery in the clinical field.

A summary with the main scientific contributions on IAC has been provided, revealing the most and least developed areas, as well as those presenting contradictory results. However, some limitations of the present paper should be mentioned. First, only English and Spanish terms were used in the bibliographic search, hence there may be articles in other languages which may have been excluded. Secondly, other search strategies would have led to other articles, thus it cannot be concluded that this work deals with every study on IAC in an exhaustive manner. Thirdly, the content analysis did not use double blind techniques; therefore, the topics proposed for articles classification are subjective. Despite these limitations, this review is, to the best of our knowledge, the first presenting a global overview of the research in the topic. It is expected to contribute to shed some light on the several lines of research on IAC and to open new horizons for further research efforts on the more problematic areas.

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