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Highlights

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The influence of mere social presence on Stroop interference: New evidence from the semantically-based Stroop task

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► We examined the influence of mere social presence on Stroop interference. ► We used both the standard and the semantically-based Stroop task. ► Mere social presence influences response competition but not the computation of semantics. ► Our results corroborate the automatic character of semantic activation in reading. ► We provide a new explanatory account of mere social presence in the Stroop task.

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Flash Report

The influence of mere social presence on Stroop interference: New evidence from the semantically-based Stroop task

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ABSTRACT

Past studies have shown that mere social presence reduces Stroop interference but processes underlying such effect are still poorly understood. Given that the standard Stroop task used in those studies confounds semantic and response competition, it remains unclear whether Stroop words are processed normally (Sharma, Booth, Brown, & Huguet, 2010) or whether the processing of their semantic representations is altered (Huguet, Galvaing, Monteil, & Dumas, 1999, Exp. 1). The direct evidence from the semantically-based Stroop task (i.e., a task that is free of response competition and thus isolates the semantic component of the Stroop interference, Neely & Kahan, 2001) provided in this paper attests normal semantic processing. Such result refutes the idea that semantic activation can be prevented or controlled by social presence and thus adds to the growing body of evidence showing that semantic activation is indeed automatic. Also importantly, this paper offers an alternative explanation of past findings, which holds that social presence simply reduces the response competition that occurs in the standard Stroop task and sheds some light on the processes that underlie social-facilitating effects of mere presence in the Stroop task.

This paper examines the influence of mere social presence on Stroop interference. In the standard Stroop task (Stroop, 1935), participants are asked to identify the color in which a target word is printed as quickly and accurately as possible. Participants' identification times are longer when the word designates a color different from the color in which it is printed (e.g., the word *BLUE* displayed in green) than when a color-neutral word is presented (e.g., *SHIP* displayed in green) because – as skilled readers – they cannot refrain from reading written stimuli and from processing their meanings (i.e., computing their lexical and semantic representations, see, e.g., Brown, Gore, & Carr, 2002).

A spectacular finding is that in the presence of a passive non-evaluative observer, this Stroop interference is importantly reduced compared to a typical "alone" condition (Huguet, Galvaing, Monteil, & Dumas, 1999, Exp. 1; Klauer, Herfordt, & Voss, 2008; Sharma, Booth, Brown, & Huguet, 2010). Huguet et al. (1999) considered such finding as "inconsistent with the widespread view (…) that lexical and semantic analyses of single words are uncontrollable" (p. 1023) and concluded that social presence can "(…) prevent the computation of semantics" (p. 1023).

This initial account challenges the commonly held assumption that the activation of the word's semantic representations in the Stroop task is *automatic* (i.e.; occurs without intent and cannot be prevented or controlled, see, e.g., Neely, 1977; Posner & Snyder, 1975; see also Moors, Spruyt, & De Houwer, 2010, for a more detailed conceptualization of automaticity). When explaining contiguous effects of the real and imaginary presence of a coactor (i.e., an individual performing the Stroop task at the same time; see e.g., MacKinnon, Geiselman, & Woodward, 1985; see also Huguet et al., 1999, Exp. 2), Huguet, Dumas, and Monteil (2004) similarly considered that the reduction of Stroop interference strengthens "(…) the view that word recognition processes are controllable" (p. 153) as the presence of a coactor "(…) could also divert attention, at least temporarily, from the semantic level, resulting in a smaller Stroop effect." (Dumas, Huguet, & Ayme, 2005, p. 8). However, both of these posterior papers also acknowledged the possibility that such reduction might not be sufficient evidence for concluding that word-level processing is altered.

Somewhat in agreement with this latter possibility, Huguet and colleagues' second and more recent account labeled *late selection account* (see Discussion and conclusion) suggests that at the early stage (i.e., semantic and lexical), Stroop words are processed normally (Sharma et al., 2010).

One of the arguments this paper attempts to make is that up to now none of these accounts received methodologically acceptable scrutiny given that Stroop interference is not only produced by semantic competition initiated by early processing of the written word, but it is also produced by response competition (Augustinova & Ferrand, 2012; De Houwer, 2003; Neely & Kahan, 2001; Schmidt & Cheesman, 2005; see also Dalrymple-Alford, 1972; Gawronski, Deutsch, LeBel, & Peters, 2008; Klein, 1964). Indeed, in *standard* incongruent trials

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(e.g., $BLUE_{green}$), not only do the semantically overlapping target (i.e., green) and distracter (i.e., blue) mismatch (i.e., they are stimulus–stimulus (SS)-incompatible), they are also response–response (RR)-incompatible. This means that in a manual Stroop task such as that used in Huguet and colleagues' past studies, there is also a great amount of competition about which key to press since blue is assigned to one key and green to another. Thus given that response and semantic competition are confounded in this task, it is impossible to verify whether Stroop words are processed normally or whether the processing of their semantic representations is altered (e.g., slowed or blocked).

Neely and Kahan's (2001) suggestion to supplement *standard* incongruent trials (e.g., $BLUE_{green}$) by also presenting words that are simply associated with an incongruent color (e.g., SKY_{green}) is one way to address such issue (see De Houwer, 2003 for another way). Indeed, *semantically-based* Stroop interference (i.e.; positive difference in mean response latencies between color-associated and color-neutral trials) isolates the semantic component of the Stroop interference since it eliminates RR-incompatibility (see Schmidt & Cheesman, 2005 for a straightforward empirical demonstration of the fact that the conflict is limited to SS-incompatibility).

A small number of studies have re-examined the factors that are thought to reduce Stroop interference within this paradigm and shown that manipulations such as focusing attention by coloring and spatially-cuing a single letter (vs. all letters) in a word[1] or instructing highly suggestible individuals to construe words as meaningless symbols,[2] for instance, do not eliminate or even reduce *semantically-based* Stroop interference (Augustinova & Ferrand, 2007, 2012; Augustinova, Flaudias, & Ferrand, 2010). In these studies, the magnitude of the semantically-based Stroop effect was found to remain constant irrespective of such manipulations. Since, in line with previous findings, these studies have also revealed a considerable reduction in the standard Stroop effect, the reported results suggest that many manipulations might simply reduce response competition.

Following on from this past work, the aim of this paper is to test this equally plausible explanation. To test directly the hypothesis that mere social presence simply reduces non-semantic response competition taking place in the standard Stroop task, the present study examined the effects of social presence on both standard and semantically-based Stroop interference. To this end, the participants performed both types of incongruent trial[3] both with and without social presence. Since the aim of Experiment 1 was to replicate and extend the work of Huguet and colleagues (Huguet et al., 1999, Exp. 1; Sharma et al., 2010) to a vocal task, the amplitude of the Stroop interference was computed by comparing the incongruent trials with the control patches ("+++++") used in these past studies. However, given that this type of control artificially inflates the Stroop interference effect (e.g., Klauer et al., 2008), a more conventional control condition consisting of neutral words was used in Experiment 2.

Experiments 1 and 2

Method

Participants and design

One hundred thirty-three female psychology undergraduates at Blaise Pascal University, Clermont-Ferrand, France took part in these experiments (41 in Experiment 1 and 92 in Experiment 2) in exchange for a course credit. All were native French speakers, had normal or corrected-to-normal vision, and were not color-blind.

Design

Both experiments involved a 2 (social presence: present vs. absent) × 3 (type of stimulus: standard incongruent vs. color-associated incongruent vs. neutral) mixed design with social presence as between-subject factor.

Procedure

Both experiments began with a set of twenty-four practice trials (performed by the participants on their own) followed by the 90 experimental trials. After the participants had completed the practice trials, the female experimenter presented those assigned to the "social presence" condition with a cover story that was identical to the one used by Sharma et al. (2010). In short, the participants performed the experimental task with a female confederate (who could not see the computer screen) in the room. She spent 60–70% of the time looking at each participant's face and hands and read a book for the remaining time. In the "alone" condition, the participants performed the task alone.

Stimuli and apparatus

In both experiments, the stimuli consisted of six color-associated words: *tomate* [tomato], *maïs* [corn], *ciel* [sky], *salade* [salad], *chocolat* [chocolate], and *carotte* [carrot]; and six color words: *rouge* [red], *jaune* [yellow], *bleu* [blue], *vert* [green], *marron* [brown], and *orange* [orange]. In Experiment 2, the neutral stimuli consisted of six neutral words: *balcon* [balcony], *robe* [dress], *pont* [bridge], *chien* [dog], *train* [train], and *studio* [studio], whereas in Experiment 1, the neutral stimuli consisted of six colored plus signs (+++++) varying in length. Their repetition resulted in thirty trials for each level of stimulus type (i.e., a total of 90 experimental trials). All the conditions varied randomly within a single block of trials throughout the experiment. All the stimuli were similar in length (5, 5.8 and 5 letters on average for the color-associated, the standard incongruent and the neutral conditions, respectively) and frequency (53, 60 and 65 occurrences per million for the color-associated, the standard incongruent and the neutral-word conditions, respectively) according to *Lexique* (New, Pallier, Brysbaert, & Ferrand, 2004). The color-associated and color words were always presented in incongruent colors (i.e., *carotte* [carrot] appeared only in red, yellow, green, brown, or blue).

The stimuli were presented individually in lowercase letters. On average, each word subtended a visual angle of 0.9° in height × 3.0° in width. At the beginning of each trial, a fixation point ("*") appeared in the center of the screen and all the stimuli were presented with the middle letter positioned at the fixation point. The participants were instructed to concentrate on the fixation point that was presented in the center of the screen for 500 ms. The entire display remained on the screen until a response was made or for a maximum of 2 s. After this response, a new stimulus appeared on the screen, again replacing the fixation point and beginning the next trial. The response–stimulus interval was 1 s (as in Sharma et al., 2010).

The participants were seated approximately 50 cm from a 17-inch Dell color monitor. Stimulus presentation and data were controlled by DMDX (Forster & Forster, 2003) run on a PC. The participants' responses (measured to the nearest millisecond) were recorded via a Koss 70 dB microphone headset and stored on the hard disk.

Results

Latencies longer than 3 SDs above or below each participant's mean latency for each condition (accounting for less than 1.9% of the total data in Experiment 1 and 1.6% in Experiment 2) were excluded from the analyses.

Correct mean naming latencies from both experiments (see Table 1) were first analyzed in a 2 (social presence: with vs. without) × 3 (type of stimulus: standard incongruent vs. color-associated incongruent vs. neutral) repeated-measures ANOVA to verify that Stroop interference

[1] See, e.g., Augustinova & Ferrand, 2007; Besner & Stolz, 1999; Brown, Joneleit, Robinson, & Brown, 2002; Manwell et al., 2004.

[2] See, e.g., MacLeod & Sheehan, 2003; Raz & Campbell, 2011; Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006.

[3] It should be noted that Huguet et al. (1999) included color-associated items. However, the proportion of these items was not matched with the standard incongruent stimuli and they were not analyzed separately.

Table 1
Mean correct response times (RT, in ms), Standard Errors (in parentheses), and Percentage Error Rates (%ER) as a function of type of stimulus and social presence in Experiments 1 and 2.

	Experiment 1 (control condition "++++")				Experiment 2 (control condition "Neutral Words")			
	Alone		Presence		Alone		Presence	
	RTs	%ER	RTs	%ER	RTs	%ER	RTs	%ER
Standard incongruent	758 (28)	1.50	705 (27)	1.74	837 (15)	3.84	845 (16)	3.69
Color associated incongruent	695 (23)	0.83	673 (22)	1.42	762 (12)	0.36	795 (15)	0.00
Neutral	617 (19)	0.33	614 (18)	0.63	744 (12)	0.07	777 (15)	0.00
Effects								
Standard Stroop effect	+141* $F(1,39) = 74.41$	1.17**	+91* $F(1,39) = 32.68$	1.11†	+92* $F(1,90) = 157.65$	3.77*	+68* $F(1,90) = 85.56$	3.69*
Cohen's *d*	1.34		0.81		1.05		0.62	
Semantic Stroop effect	+78* $F(1,39) = 49.15$	0.50	+59* $F(1,39) = 29.30$	0.79	+18* $F(1,90) = 17.22$	0.29	+18* $F(1,90) = 18.72$	0.00
Cohen's *d*	0.89		0.58		0.21		0.17	

RT = reaction time; %ER = percentage error rates; Cohen's *d* = effect size based on Cohen (1988).
Q2 ** $p<0.05$
* $p<0.001$.

had occurred. This analysis confirmed that all standard and semantically-based Stroop effects were significant in both experiments (see Table 1) and therefore indicated that a significant amount of semantic processing occurred in all conditions.

In order to test our specific predictions about the effects of social presence, computed magnitudes of Stroop interferences and differences in percentages of error (see Table 1) were subsequently analyzed in a 2 (type of Stroop interference: standard vs. semantically-based) × 2 (social presence: with vs. without) repeated-measures ANOVA.

In Experiment 1, these analyses revealed a significant main effect of type of interference, $F(1, 39) = 23.37$; $p<0.001$, $\eta_p^2 = 0.38$. Even though the type of interference × social presence interaction was not significant, $F(1, 39) = 2.43$; $p = 0.13$, *ns*, the planned comparison of the simple main effect of social presence at each level of Stroop interference followed the expected pattern: social presence significantly reduced the magnitude of standard Stroop interference, $F(1, 39) = 4.76$; $p<0.05$, $\eta_p^2 = 0.11$; but had no effect on semantically-based Stroop interference, $F(1, 39) = 1.53$; $p = 0.23$, *ns*. The same analysis performed on differences in percentages of error did not yield any significant results. This type of pattern is consistent with the idea that the reduction caused by social presence is not due to an increase in the percentage of errors.

In Experiment 2, the main effect of type of interference, $F(1, 90) = 165.01$; $p<0.0001$, $\eta_p^2 = 0.65$ and the type of interference × social presence interaction, $F(1, 90) = 6.67$; $p = 0.011$, $\eta_p^2 = 0.07$ were both significant. Again, the planned comparison of the simple main effect of social presence at each level of Stroop interference followed the expected pattern: social presence significantly reduced the magnitude of standard Stroop interference, $F(1, 90) = 5.47$; $p<0.05$, $\eta_p^2 = 0.06$; but had no effect on semantically-based Stroop interference, $F(1, 90) = 0.02$; $p = 0.90$, *ns*. The same analysis performed on differences in percentages of error revealed only a significant main effect of type of interference, $F(1, 90) = 51.45$; $p<0.001$, $\eta_p^2 = 0.36$. This result suggests that the reduction in Stroop interference is not due to an increase in the percentage of errors.

Discussion and conclusion

The present experiments closely replicated the work of Huguet and colleagues (Huguet et al., 1999; Sharma et al., 2010) showing that social presence reduces standard Stroop interference. This replication is important since it generalizes past findings to a vocal task in which (in Experiment 2) the more conventional color-neutral words were used as control stimuli.

More critically and against the initial claim made by Huguet et al. (1999) that social presence can prevent the computation of semantics, both experiments revealed significant semantically-based Stroop interference in all conditions. Moreover, magnitudes of these interferences remained unchanged by social presence, which again is incompatible with the idea that word recognition processes are controllable (Dumas et al., 2005; Huguet et al., 2004).

This pattern of results is consistent with our claim that the social presence influences a response competition mechanism (as shown by the simultaneous reduction of standard Stroop interference). Consequently, they add to the growing body of evidence suggesting that semantic activation in the Stroop task is indeed automatic and ballistic in the sense that it occurs without intent and cannot be prevented or controlled (e.g. Augustinova & Ferrand, 2007, 2012; Augustinova et al., 2010; Brown, Gore, et al., 2002; Brown, Joneleit, et al., 2002; Heil, Rolke, & Pecchinenda, 2004; Küper & Heil, 2008; Tse & Neely, 2007).

Interestingly, Wühr and Huestegge (2010), who investigated the impact of social presence on the processing of visuospatial information in the *spatial-cuing paradigm* (Posner, 1980), recently concluded that the apparently automatic processing of physical cues (unlike that of symbolic cues whose processing is dependent on working memory) is unaffected by social presence. In short, these findings, taken in combination with those reported in the present paper, provide converging evidence that social presence on its own is not able to influence automated processes.

At this point, an important conclusion can be drawn from the results reported above: even though a number of very interesting studies have indicated that semantic activation (hereafter SA) in the Stroop task is reduced by socio-cognitive factors such as mere social presence (Huguet et al., 1999, Exp. 1), real or imaginary presence of a coactor (Dumas et al., 2005; Huguet et al., 1999, Exp. 2; Huguet et al., 2004) or the social priming of dyslexia (Goldfarb, Aisenberg, & Henik, 2011), they are clearly inconclusive with regard to the automaticity of SA (and therefore the automaticity of word reading). Indeed, they all suffer from the fact that SA is measured in an inappropriate way (Neely & Kahan, 2001). It seems premature to claim that semantic activation can be prevented by contextual factors and it is clearly speculative to do so in cases where only the standard Stroop task is used (see also De Houwer, 2011).

To conclude, our results also shed some additional light on the *late selection* account that has been favored by Sharma et al. (2010). As mentioned previously, this account holds that Stroop words are processed normally but the distractor is strongly inhibited before a response is selected. When exactly this inhibition takes place still remains an unsolved issue.

Broadly in line with Manwell, Roberts, and Besner (2004) it is plausible that social presence, and the narrowing of attention that it entails, helps to separate the products resulting from the processing of the color and word dimensions and potentially inhibits the irrelevant word dimension. Yet, if the distractor is inhibited before

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RR-competition, it should logically influence SS-competition and thus reduce semantically-based Stroop effect as well. The magnitude of this effect remaining the same irrespective of social presence (see also Augustinova & Ferrand, 2007, 2012; Augustinova et al., 2010) runs against the idea that inhibitory processes are taking place *before* response competition.

We believe instead that social presence simply influences response competition. Within this perspective, it is plausible that the narrowing of attention resulting from social presence permits better adaptation to the task-specific response criteria since it might enable individuals to exert additional control over what is done with various kinds of automatically computed information (see e.g., Cateña, Fuentes, & Tudela, 2002, for a demonstration of this type of possibility). It is also plausible that in the vocal task, social presence modulates the activation of articulatory codes (Neely & Kahan, 2001) by boosting the inhibition of the irrelevant code.

To sum up, the above explanations, all of which require further empirical scrutiny, are still consistent with the account in terms of inhibition proposed by Sharma et al. (2010). However, these explanations diverge when it comes to identifying exactly what is inhibited by social presence. In sum, these different research directions provide potentially fruitful avenues that will enable us to gain a better understanding of both social-facilitating effects of mere presence (Zajonc, 1965) and of Stroop interference.

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