Socially-Shared Retrieval-Induced Forgetting in the Presence of Others

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Abstract

In social interactive retrieval groups, a speaker' s selective retrieval may lead to listeners' forgetting of relevant but unmentioned content, which is termed social sharing-induced forgetting. Experiment 1 of this study first examined the influence of the presence or absence of real others on social sharing-induced forgetting. The results showed that this phenomenon only emerged under conditions of real others' presence, indicating that social sharing-induced forgetting is influenced by listeners' bottom-up processing of social interaction contexts. Experiment 2 further investigated the impact of individuals' inhibitory control ability on social sharing-induced forgetting under conditions of others' presence. The results revealed that this phenomenon was only related to the magnitude of the individual retrieval-induced forgetting effect when they served as speakers, suggesting that social sharing-induced forgetting, similar to the individual retrieval-induced forgetting process, is influenced by individuals' top-down unintentional inhibitory ability to exclude competing items from intruding into memory. The findings provide important insights for understanding the formation and alteration of individual memory in interpersonal communication contexts.

Full Text

Socially Shared Retrieval-Induced Forgetting in the Presence of Others

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Abstract
In social interaction contexts, selective retrieval by speakers can cause listeners to forget unmentioned but related information, a phenomenon termed socially shared retrieval-induced forgetting (SS-RIF). Experiment 1 examined how the physical presence of others influences SS-RIF, revealing that this effect only emerges when a real person is present, suggesting that SS-RIF is affected by listeners' processing of bottom-up social interaction contexts. Experiment 2 further investigated how individual inhibitory control capacity affects SS-RIF in the presence of others, finding that the phenomenon relates only to the magnitude of an individual' s own retrieval-induced forgetting effect when serving as speaker. This indicates that SS-RIF, similar to individual retrieval-induced forgetting, is influenced by top-down unintentional inhibitory capacity to exclude competitive items from memory. These findings provide important insights into how individual memory is formed and modified in interpersonal communication contexts.

Keywords: socially shared retrieval-induced forgetting; presence of others; inhibitory control; unintentional inhibition

In everyday life, people frequently converse with spouses, family members, friends, and even strangers about past experiences or acquired knowledge. During such conversations, the content is typically selected by the person who initiates the topic. However, due to the speaker' s own forgetting or other specific reasons, the topic initiator may intentionally or unintentionally engage in selective retrieval of certain information. Research on the speaker's own memory has shown that this selective retrieval of information leads to forgetting of specific information in the speaker, a phenomenon known as retrieval-induced forgetting (RIF). Anderson, Bjork, and Bjork (1994) consider this an inherent property of memory behavior. Previous research both domestically and internationally has demonstrated that RIF resulting from selective retrieval practice is a universal phenomenon (Anderson et al., 1994).

Interestingly, in dyadic or multi-person retrieval groups, research on listeners other than the speaker has found that listening to others' retrieval can cause listeners to forget specific information (Bai, Mao, & Li, 2016). Cuc, Koppel, and Hirst (2007) termed this phenomenon—where a speaker' s retrieval of certain information causes listeners to forget related information—socially shared retrieval-induced forgetting (SS-RIF). Regarding the cognitive explanation of this phenomenon, some researchers argue that its cognitive mechanism is similar to that of the speaker' s RIF (Bai et al., 2016). That is, during selective retrieval, speakers engage in a top-down controlled retrieval process that simultaneously involves activation of target items and inhibition of competitive items. This dual-process model of activation and inhibition ensures successful retrieval of target items (Badre & Wagner, 2007). Similarly, in social interaction retrieval

groups, researchers speculate that listeners monitor in real-time and "implicitly" engage in a controlled retrieval process similar to that of speakers, subsequently showing retrieval advantages for target items and long-term inhibition of competitive items in individual retrieval tasks (Zhang et al., 2018). However, in social interaction retrieval groups, SS-RIF does not always occur with the speaker's selective retrieval (Bai et al., 2016; Abel & Bäuml, 2019). Therefore, exploring the conditions and underlying cognitive processes of SS-RIF in social interaction retrieval groups is crucial for understanding the development of this social memory phenomenon.

To investigate the conditions for SS-RIF occurrence, Cuc et al. (2007) first designated one member as "speaker" and another as "listener" in a real interactive dyadic retrieval group, with both completing interactive retrieval practice in fixed roles. Additionally, they controlled the listener's monitoring level of the speaker's retrieval practice items by requiring listeners to monitor the accuracy and fluency of the speaker's retrieval items and provide feedback. In the final individual retrieval test, results showed that speakers exhibited RIF across all experimental conditions; however, SS-RIF only appeared in groups where listeners were required to monitor the accuracy of the speaker's retrieval practice items. Further, Koppel and Storm (2014) found that when instructions did not explicitly require listeners to monitor the speaker's retrieval items, most listeners still actively participated in the speaker's retrieval practice process during real interactive retrieval and "implicitly" completed retrieval tasks with the speaker, subsequently showing stable SS-RIF effects in the final retrieval test. Domestic researchers using Chinese category-exemplar two-character words as experimental materials similarly found that listeners' participation level in retrieval practice tasks (semantic or orthographic accuracy judgment) affected the degree of memory impairment for specific items (Zhang, Fu, Zhang, & Shi, 2017). These behavioral studies, which manipulated the condition of real others' presence, consistently found that listeners' monitoring level of the speaker's retrieval items or their participation level in retrieval practice tasks were important factors influencing whether SS-RIF occurred, showing cross-cultural consistency.

Another group of researchers, using cognitive neuroscience methods, attempted to explore the influence of "others'" retrieval content on individual memory in laboratory-simulated "social interaction" contexts. In these studies, researchers typically used audio or video to replace the "speaker" in real interactive contexts, making listeners in functional magnetic resonance imaging (fMRI) equipment believe they were in a real-time interactive retrieval situation with a "speaker." Results showed that in this interactive retrieval process without real others' presence (audio playback of the speaker's retrieval content), listeners' spontaneous neural activity patterns similar to those of the speaker, generated through careful listening, affected listeners' final memory outcomes (Zadbood et al., 2017; see similar studies in Silbert et al., 2014; Stephens et al., 2010). Therefore, these cognitive neuroscience studies, which manipulated the condition of no real others' presence, found that as long as listeners were required to carefully monitor the "speaker's" recall content, listeners' cognitive processes and neural activities

would undergo processes similar to those of the "speaker," thereby affecting final memory retrieval outcomes.

Thus, previous studies using behavioral or cognitive neuroscience methods have either manipulated real others' presence or absence to explore listeners' cognitive processes and influencing factors in these "social interaction" contexts. The a priori assumption of these studies was that the presence or absence of real others has little impact on the level of social interaction and, consequently, can be ignored in its effect on individual memory. However, with the development of social cognitive neuroscience, particularly the advancement of the "second-person approach" in social cognition research (Schilbach, 2019; Schilbach et al., 2013), increasing attention has been paid to the basic processes and patterns of social interaction in naturalistic contexts and how such interpersonal communication affects individual memory and behavior. In real interactive dyadic or multi-person memory retrieval processes, the social interaction between speaker and listener is always an "online" information transmission process (Scholkmann et al., 2013). Recent studies have shown that real others' presence (such as eye contact, facial expression production and recognition, turn-taking, etc.) affects neural signal synchronization among multiple individuals in a group during cooperative tasks, subsequently influencing their behavioral performance in social cognition tasks (Cui et al., 2012; Dai et al., 2018; Jiang et al., 2012; Zheng et al., 2018), with similar evidence in social memory tasks (Dikker et al., 2014). Therefore, based on recent findings from social cognitive neuroscience, it can be inferred that whether real others are present affects individual memory processes and outcomes by altering the level of interpersonal social interaction. In other words, only when a real speaker is present will listeners be influenced by social interaction and engage in a "speaker-like" implicit selective retrieval process, subsequently exhibiting SS-RIF.

In summary, based on previous behavioral or individual cognitive neuroscience research, one might infer that the presence or absence of real others does not change the level of social interaction and, consequently, does not affect listeners' memory processes and outcomes. That is, as long as listeners carefully monitor the "speaker' s" retrieval content, they should exhibit psychological and neural processes similar to those of the speaker, thereby showing SS-RIF. However, according to recent social cognitive neuroscience findings, compared to conditions without real others' presence, real others' presence affects listeners' memory outcomes by influencing the level of social interaction among retrieval group members. In other words, only under conditions where a real speaker is present will listeners be affected by social interaction, engage in a "speaker-like" implicit selective retrieval process, and subsequently exhibit SS-RIF.

Accordingly, Experiment 1 of this study, based on the classic retrieval practice paradigm, manipulated two levels of social interaction: real others' presence versus absence (using pre-recorded standardized audio materials), requiring listeners to carefully monitor the "speaker' s" retrieval content in both conditions. The aim was to explore the boundary conditions for SS-RIF occurrence, partic-

ularly whether the bottom-up social contextual factor of real others' presence influences and constrains the emergence of SS-RIF.

Additionally, building on Experiment 1, Experiment 2 further explored whether, in addition to the social interaction contextual factor of others' presence, top-down cognitive regulation factors from the individual also play a role in SS-RIF. Previous research has found that listeners' SS-RIF shares similarities with speakers' RIF in cognitive processes (Bai et al., 2016). Studies on speakers' RIF have found that individual RIF levels are typically related to executive control levels (Aslan & Bäuml, 2012; Aslan & Bäuml, 2011; Ortega et al., 2012), particularly inhibitory control capacity within the executive control system, which researchers believe is generally significantly correlated with individuals' RIF levels (i.e., the ability to inhibit irrelevant information) (Anderson et al., 1994). Therefore, in addition to social interaction level (speaker presence), top-down inhibitory control factors related to individual memory retrieval may also be key factors causing SS-RIF to occur in social interaction contexts (Abel & Bäuml, 2019). Thus, in Experiment 2, researchers further explored whether listeners'"implicit" controlled retrieval process in real interactive retrieval groups is similar to speakers' explicit controlled retrieval process, both being affected by top-down specific inhibitory control types at the individual level.

2.1 Experimental Hypothesis

Across different experimental conditions, speakers will exhibit retrieval-induced forgetting. Furthermore, according to social cognitive neuroscience research, even though listeners are required to carefully monitor the speaker' s retrieval content across conditions, SS-RIF will only occur when a real speaker is present.

2.2.1 Participants

Using G*Power 3.1 software and referencing previous SS-RIF research (Cuc et al., 2007) that used category-exemplar word lists to determine the effect size for the main effect of item type (f = 0.5, Experiment 1), and following Cohen' s (1988) definitions of effect sizes, we set a medium effect size of f = 0.3. This indicated that a sample size of 112 would achieve statistical power of 0.95 for the main effect of item type at = 0.05.

Therefore, this experiment recruited 116 participants from a university (aged 18–26 years, mean age = 20.21, SD = 1.44, including 79 females). The experimenter randomly assigned 60 participants (mean age = 20.33, SD = 1.43, including 33 females) to the real others' presence group, while the remaining 56 participants (mean age = 20.54, SD = 1.49, including 46 females) were assigned to the no real others' presence group. Due to missing experimental data from one male participant in the no real others' presence group during the formal memory retrieval experiment, the final valid data for this group consisted of 55 participants (mean age = 20.07, SD = 1.43, including 46 females). To avoid potential extraneous effects of social relationships and social purposes on memory

outcomes, this study paired participants based on the principle of same-gender strangers across different social interaction level conditions (see similar operations in Barber & Rajaram, 2011a; Barber & Rajaram, 2011b; Finlay et al., 2000).

All participants were right-handed, had normal or corrected-to-normal vision, and were native Chinese speakers. Before the formal experiment began, all participants signed informed consent forms and received monetary compensation after completing the experiment.

2.2.2 Experimental Materials

Twelve semantic categories were selected from Liu' s (2013) Chinese category-exemplar word database. For each category, three high-taxonomic-frequency items and three low-taxonomic-frequency items were selected based on taxonomic frequency (the degree of association between exemplar words and categories), totaling 72 exemplar words as experimental materials. Additionally, three categories were selected as filler materials and two categories as practice materials. In each category, all exemplar words consisted of two Chinese characters with unique initial character pronunciations and orthographic forms, and all exemplar words were low-frequency words. Before the experiment, 20 psychology graduate students who did not participate in the formal experiment re-evaluated the association degree between each exemplar word and its category using Battig and Montague' s (1969) rating method. Results showed significant differences in category association between high- and low-taxonomic-frequency items within each category ($t(70) = -10.05$, $p < 0.001$). Furthermore, exemplar words within each category did not differ significantly in familiarity, initial character stroke count, or final character stroke count.

2.2.3 Experimental Design

Experiment 1 employed a 2 (interactive level: real others' presence, no real others' presence) × 2 (interactive role: speaker, listener) × 4 (item type: Rp+, Nrp+, Rp−, Nrp−) mixed experimental design. Interactive level was a between-subjects variable, while interactive role and item type were within-subjects variables. The dependent variable was participants' correct recall rate in the final recall test.

In the experimental retrieval practice phase, items where both category and exemplar words received retrieval practice were designated as Rp+ items; items where only category words received retrieval practice while exemplar words did not were designated as Rp− items; and items where neither category nor exemplar words received retrieval practice were designated as Nrp items (Bai & Liu, 2013). In this study, to control for the influence of exemplar words' association degree (taxonomic frequency) with category words on experimental results, we followed previous research methods by dividing Nrp categories into high-association words (Nrp−) and low-association words (Nrp+) (Wimber et

al., 2008). This operation also excluded the influence of word frequency effects on retrieval-induced forgetting. Participants in the retrieval practice phase were required to retrieve low-association exemplar words (Rp+ items). If the final recall rate for Rp+ items was higher than that for low-association exemplar words (Nrp+ items) in unpracticed categories, this indicated a retrieval practice effect. If participants' final recall rate for high-association exemplar words (Rp− items) was lower than that for high-association exemplar words (Nrp− items) in unpracticed categories, this indicated retrieval-induced forgetting.

2.2.4 Experimental Procedure

Before the formal experiment began, participants completed a practice phase. After fully understanding the experimental procedure, they began the formal experiment, which consisted of four phases: study, interactive retrieval practice, distraction, and final recall test.

In the real others' presence condition, both speaker and listener sat in the same laboratory at a 90° angle facing the same computer monitor. During the retrieval practice phase, the speaker was required to orally complete exemplar word cues that only presented the initial character, while the listener was required to close their eyes and carefully listen to the speaker' s retrieval content. The retrieval practice phase consisted of two rounds to allow role rotation between the two participants (see experimental flow in Figure 1 [Figure 1: see original paper]). Participants in the no real others' presence group completed the experimental task alone in the laboratory facing the computer. During the retrieval practice phase, the computer played pre-recorded audio materials recorded by same-gender experimental assistants. The retrieval practice phase also consisted of two rounds, requiring participants to alternately assume speaker and listener roles to complete oral completion or listening tasks with the "other." Across different interactive level conditions, participants in the "listener" role were required to carefully monitor the "speaker' s" retrieval content. After completing the experimental task, all participants' group preference, task engagement, and empathy traits were measured. The following describes the entire experimental procedure using the real others' presence condition as an example:

In the study phase, two participants individually studied 72 exemplar words under 12 different categories (e.g., jewelry-ring, animal-fox, occupation-police). These stimuli were presented in pseudorandom order, ensuring that two consecutively presented exemplar words belonged to different categories. No communication was allowed during the study process.

In the interactive retrieval practice phase, the computer randomly designated one participant as the speaker and the other automatically became the listener. During this phase, the speaker was required to orally complete presented exemplar word cues (e.g., jewelry-ri_, occupation-se_), while the listener was required to close their eyes and listen carefully. Each retrieval practice phase included 11 trials; the first and eleventh trials were filler words, while the middle

nine trials were pseudorandom combinations of three low-association exemplar words (Rp+ items) from the same category, each retrieved three times. The retrieval practice phase consisted of two rounds with role rotation.

To exclude short-term memory effects, a distraction task followed the retrieval practice phase, during which both participants individually completed two-digit addition and subtraction math problems and orally reported their answers.

In the final recall test phase, participants were required to recall as many previously studied exemplar words as possible. Each category name was presented six times (e.g., jewelry-___), and participants were asked to report corresponding exemplar words.

2.2.5 Post-Test Tasks and Measures

After completing the formal experiment, participants in different experimental conditions were measured for group preference, task engagement, and empathy traits: (1) The Group Preference Scale developed by Larey and Paulus (1999) was used to measure all participants'cooperative tendencies. The scale's internal consistency Cronbach's coefficient was 0.81. (2) The self-evaluation model scale developed by Xue, Lu, and Hao (2018) was used to measure all participants' engagement and emotional preference for this experiment. The scale' s internal consistency Cronbach' s coefficient was 0.77. (3) The Empathy Quotient (EQ) questionnaire developed by Simon and Sally (2004) was used as a tool to measure participants' empathy quotient. The scale' s internal consistency Cronbach' s coefficient was 0.81.

2.3.1 Differences in Post-Test Variables Across Experimental Conditions

Separate analyses of group preference, engagement, and empathy scale results for participants in the real others' presence and no real others' presence groups revealed no significant differences between the two groups in group preference level, engagement, or empathy (t_group_preference(113) = 0.18, p = 0.855; t_engagement(113) = 1.08, p = 0.282; t_empathy(113) = 0.38, p = 0.704). This indicates that the manipulation of social interaction level in this experiment was effective, as it only changed the factor of others' presence while controlling for the influence of other social factors such as group preference, engagement, and empathy on individual memory retrieval performance.

2.3.2 Speakers' Memory Retrieval Performance Across Experimental Conditions

Analysis of speakers' retrieval practice accuracy during the retrieval practice phase (see Table 1) revealed no significant difference in speakers'correct retrieval rates across the two experimental conditions (t(113) = 1.38, p = 0.170).

Table 1 Speakers' Retrieval Practice Accuracy Across Experimental Conditions

Condition	Accuracy (%)
No real others' presence	
Real others' presence	

A repeated measures ANOVA on speakers' correct recall rates for Rp+ and Nrp+ items in the final recall test (see Table 2) showed a significant main effect of item type, F(1, 113) = 618.56, p < 0.001, ^{2}_p = 0.846, 95% CI = [0.39, 0.46], indicating that speakers' correct recall rates for Rp+ items were higher than those for Nrp+ items across experimental conditions. Neither the main effect of interactive level (F(1, 113) = 1.79, p = 0.184) nor the interaction between item type and interactive level (F(1, 113) = 1.95, p = 0.166) was significant.

Following the purpose of this study and previous research experience (Anderson et al., 1994; Liu, Yue, & Bai, 2019), we used planned comparisons (Shu & Zhang, 2008) to conduct paired-sample t-tests on speakers' correct recall rates for Rp+ and Nrp+ items under the two interactive levels. Results showed that speakers' correct recall rates for Rp+ items were significantly higher than those for Nrp+ items under both interactive levels (t_no_real_others(54) = 15.43, p < 0.001, d = 2.082, 95% CI = [0.35, 0.46]; t_real_others(59) = 20.02, p < 0.001, d = 2.580, 95% CI = [0.41, 0.50]) (Figure 2 [Figure 2: see original paper] left). This indicates that participants exhibited classic retrieval-induced enhancement (i.e., retrieval practice effect) when serving as speakers under both experimental conditions.

Table 2 Speakers' Correct Recall Rates for Rp+, Nrp+, Rp−, and Nrp− Items Across Experimental Conditions (M ± SD)

Item Type	No Real Others' Presence	Real Others' Presence
Rp+	0.78 ± 0.15	0.77 ± 0.15
Nrp+	0.37 ± 0.14	0.32 ± 0.14
Rp−	0.49 ± 0.18	0.44 ± 0.18
Nrp−	0.53 ± 0.12	0.51 ± 0.15

Subsequent repeated measures ANOVA on speakers' correct recall rates for Rp− and Nrp− items in the final recall test (see Table 2) revealed a significant main effect of item type, F(1, 113) = 9.90, p = 0.002, ^{2}_p = 0.081, 95% CI = [−0.08, −0.02], indicating that speakers' correct recall rates for Rp− items were significantly lower than those for Nrp− items across experimental conditions. Neither the main effect of interactive level (F(1, 113) = 1.64, p = 0.204) nor the interaction between item type and interactive level (F(1, 113) = 0.41, p = 0.523) was significant.

Following the purpose of this study and previous research experience (Anderson et al., 1994; Liu et al., 2019), we used planned comparisons to conduct paired-sample t-tests on speakers' correct recall rates for Rp− and Nrp− items under

different interactive levels. Results showed that in the no real others' presence condition, speakers' correct recall rates for Rp− items were marginally significantly lower than those for Nrp− items ($t(54) = -1.87$, $p = 0.067$, $d = 0.247$, 95% CI = [−0.08, 0]); in the real others' presence condition, speakers' correct recall rates for Rp− items were significantly lower than those for Nrp− items ($t(59) = -2.58$, $p = 0.013$, $d = 0.385$, 95% CI = [−0.12, −0.01]) (Figure 2 [Figure 2: see original paper] right). This indicates that participants exhibited classic retrieval-induced forgetting when serving as speakers under both social interaction level conditions.

Figure 2 Speakers' Correct Recall Rates for Rp+, Nrp+, Rp−, and Nrp− Items Across Experimental Conditions
(Note: # $p = 0.067$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, the same below.)

2.3.3 Listeners' Memory Retrieval Performance Across Experimental Conditions

A repeated measures ANOVA on listeners' correct recall rates for Rp+ and Nrp+ items in the final recall test (see Table 3) showed a significant main effect of item type, $F(1, 113) = 559.98$, $p < 0.001$, $^2\_p = 0.832$, 95% CI = [0.35, 0.41], indicating that listeners' correct recall rates for Rp+ items were higher than those for Nrp+ items across experimental conditions. Neither the main effect of interactive level ($F(1, 113) = 0.13$, $p = 0.021$) nor the interaction between item type and interactive level ($F(1, 113) = 0.90$, $p = 0.346$) was significant.

Following the purpose of this study, we used planned comparisons to conduct paired-sample t-tests on listeners' correct recall rates for Rp+ and Nrp+ items under the two interactive levels. Results showed that listeners' correct recall rates for Rp+ items were significantly higher than those for Nrp+ items under both interactive levels ($t\_no\_real\_others(54) = 15.61$, $p < 0.001$, $d = 2.114$, 95% CI = [0.32, 0.41]; $t\_real\_others(59) = 17.92$, $p < 0.001$, $d = 2.310$, 95% CI = [0.35, 0.44]) (Figure 3 [Figure 3: see original paper] left). This indicates that participants exhibited classic retrieval-induced enhancement (i.e., "implicit" retrieval practice effect) when serving as listeners under both experimental conditions.

Table 3 Listeners' Correct Recall Rates for Rp+, Nrp+, Rp−, and Nrp− Items Across Experimental Conditions (M ± SD)

Item Type	No Real Others' Presence	Real Others' Presence
Rp+	0.74 ± 0.15	0.72 ± 0.18
Nrp+	0.37 ± 0.14	0.32 ± 0.14
Rp−	0.52 ± 0.18	0.47 ± 0.18
Nrp−	0.53 ± 0.12	0.51 ± 0.15

Subsequent repeated measures ANOVA on listeners' correct recall rates for Rp−

and Nrp− items in the final recall test (see Table 3) revealed no significant main effect of item type ($F(1, 113) = 2.52$, $p = 0.116$), no significant main effect of interactive level ($F(1, 113) = 2.11$, $p = 0.149$), and no significant interaction between the two ($F(1, 113) = 1.08$, $p = 0.300$).

Therefore, following the purpose of this study, we used planned comparisons to conduct further paired-sample t-tests on listeners' correct recall rates for Rp− and Nrp− items. Results showed that in the no real others' presence condition, there was no significant difference between listeners' correct recall rates for Rp− and Nrp− items ($t(54) = -0.35$, $p = 0.732$). However, in the real others' presence condition, listeners' correct recall rates for Rp− items were significantly lower than those for Nrp− items ($t(59) = -2.10$, $p = 0.040$, $d = 0.273$, 95% CI = [−0.08, 0]) (Figure 3 [Figure 3: see original paper] right). This indicates that under the experimental manipulation conditions, different social interaction levels affect whether SS-RIF occurs; that is, only when a real speaker is present do listeners exhibit SS-RIF.

Figure 3 Listeners' Correct Recall Rates for Rp+, Nrp+, Rp−, and Nrp− Items Across Experimental Conditions

The results of Experiment 1 showed that across different experimental conditions, speakers exhibited memory inhibition effects for competitive items due to selective retrieval practice in the final recall test (i.e., RIF). However, compared to the no real others' presence condition, only in the real others' presence condition did listeners exhibit memory inhibition effects for competitive items that the speaker did not practice but that were related (i.e., SS-RIF). This result is consistent with the experimental hypothesis, emphasizing the influence of the bottom-up social contextual factor of real speaker presence on SS-RIF and supporting relevant inferences from social cognitive neuroscience.

The results of Experiment 1 demonstrated the boundary conditions for SS-RIF occurrence from the perspective of social contextual factors. However, to truly examine the cognitive process of SS-RIF—specifically, whether listeners' "implicit" controlled retrieval process actually occurs under real others' presence conditions—Experiment 1 cannot provide a definitive answer. Only by clearly analyzing the similar or different cognitive effects of speakers' retrieval practice on both speakers and listeners in social interaction contexts can we truly test the "implicit retrieval" hypothesis and provide more direct evidence for the cognitive mechanism of SS-RIF.

Therefore, building on Experiment 1, Experiment 2 further explored the influence of top-down individual inhibitory control factors on SS-RIF. The experimental results will advance understanding of the important role of individual differences (particularly inhibitory control) on memory processes and outcomes in social interaction contexts.

3.1 Experimental Hypothesis

Compared to the no real others' presence condition, in retrieval groups with real others' presence, listeners' SS-RIF will be significantly correlated with the magnitude of their own individual RIF when serving as speaker. That is, both cognitive processes will be affected by individual inhibitory control (particularly the cognitive inhibitory ability to intentionally suppress irrelevant information from working memory or attention).

3.2.2 Inhibitory Control Test Tasks and Measures

Nigg (2000) divided inhibitory control processes into four types: interference control, cognitive inhibition, behavioral inhibition, and oculomotor inhibition. The inhibitory control processes related to memory retrieval tasks mainly include the first three types.

(1) Interference Control
This study used the classic Stroop color-word paradigm as a tool to measure interference control. Following previous research, we calculated the Stroop effect size using accuracy rates under congruent and incongruent conditions ([accuracy in congruent condition − accuracy in incongruent condition] / accuracy in congruent condition) (Liu & Bai, 2017).

(2) Cognitive Inhibition
The directed forgetting research paradigm was used as a tool to measure cognitive inhibition. Participants' remember rate (recall rate for "to-be-remembered" [TBR] items) and forget rate (recall rate for "to-be-forgotten" [TBF] items) were calculated. For subsequent data analysis, participants' remember and forget rates were computed as "(remember rate − forget rate) / remember rate."

(3) Behavioral Inhibition
The classic Stop Signal Task was used as a tool to measure behavioral inhibition, including go trials and stop trials. In subsequent data analysis, the Stop Signal task used four indicators: successful inhibition rate, critical stop signal delay (SSD), go trial reaction time (Go RT), and stop signal reaction time (SSRT) (Fang et al., 2013). The calculation of stop signal reaction time referenced previous research methods (Go RT − critical SSD) (Li et al., 2016).

3.2.3 Experimental Procedure

To avoid mutual influence between memory retrieval tasks, all tasks in Experiment 2 were conducted 7 days after the formal experiment in Experiment 1 (see similar research in Finn et al., 2018).

3.2.4 Post-Test Tasks and Measures

After completing the inhibitory control tests, the Operation-Word Span Task (OWST) was used to measure working memory capacity for all participants across experimental conditions.

3.3.1 Descriptive Statistical Analysis of Inhibitory Control Variables Across Experimental Conditions

Independent samples t-tests on participants' inhibitory control variables across experimental conditions (see Table 4) revealed no significant differences between the two groups in any inhibitory control variables (t_directed_forgetting(113) = 0, p = 0.997; t_Stroop_effect(113) = −1.41, p = 0.162; t_Stop_signal_SSRT(113) = 0.29, p = 0.776; t_Stop_signal_Go_RT(113) = 1.18, p = 0.239; t_Stop_signal_critical_SSD(113) = 0.44, p = 0.659; t_Stop_signal_successful_inhibition_rate(113) = −0.28, p = 0.780).

Table 4 Participants' Scores on Inhibitory Control Variables Across Experimental Conditions (M ± SD)

Inhibitory Control Variable	No Real Others' Presence	Real Others' Presence
Stroop effect size	0.78 ± 0.29	0.78 ± 0.39
Directed forgetting	0.01 ± 0.04	0.02 ± 0.05
Stop signal-SSRT	148.23 ± 88.39	143.73 ± 80.67
Stop signal-Go RT	484.59 ± 61.40	470.40 ± 66.80
Stop signal-Critical SSD	336.36 ± 118.03	326.67 ± 116.98
Stop signal-Successful inhibition rate	0.53 ± 0.09	0.53 ± 0.12

3.3.2 Correlations Between Inhibitory Control Variables and Memory Retrieval Performance Across Experimental Conditions

We conducted correlation analyses between participants' inhibitory control variables and the relative impairment values of individual RIF and SS-RIF across experimental conditions. Tables 5 and 6 show the partial correlations between inhibitory control variables and retrieval-induced forgetting relative impairment values after controlling for working memory variables across experimental conditions. Results showed that in the no real others' presence condition, no significant correlations existed between any variables except for internal correlations among stop signal variables (see Table 5). In the real others' presence condition, however, the RIF relative impairment value was significantly negatively correlated with the SS-RIF relative impairment value (r = −0.31, p = 0.018) (see Table 6).

[1]This experiment calculated the relative memory impairment value induced by the retrieval process ([p(Nrp−) − p(Rp−)] / p(Nrp−)) following Cuc et al.' s (2007) method. If the formula used the participant' s Rp− correct recall rate when serving as speaker, the result represented the relative impairment value of individual retrieval-induced forgetting (RIF); if the formula used the participant' s Rp− correct recall rate when serving as listener, the result represented the

relative impairment value of socially shared retrieval-induced forgetting (SS-RIF).

Table 5 Partial Correlations Between Inhibitory Control Variables and Relative Impairment Values in the No Real Others' Presence Condition

Variable	Directed Forgetting	Stroop	Go RT	Critical SSD	Successful Inhibition Rate	SS-RIF
Directed Forgetting	1					
Stroop	−0.07	1				
Go RT	−0.05	0.66***	1			
Critical SSD	0.53***	0.72***	−0.18	1		
Successful Inhibition Rate	−0.86***	−0.58***	0.01	−0.05	1	
SS-RIF	−0.04	−0.04	−0.06	−0.13	−0.12	1

Table 6 Partial Correlations Between Inhibitory Control Variables and Relative Impairment Values in the Real Others' Presence Condition

Variable	Directed Forgetting	Stroop	Go RT	Critical SSD	Successful Inhibition Rate	SS-RIF
Directed Forgetting	1					
Stroop	−0.08	1				
Go RT	0.75***	0.68***	1			
Critical SSD	0.67***	−0.24	−0.25	1		
Successful Inhibition Rate	−0.83***	−0.40**	−0.31*	0.75***	1	
SS-RIF	−0.09	−0.10	−0.05	−0.11	−0.31*	1

Experiment 2, building on Experiment 1, administered a series of inhibitory control tasks to participants after the retrieval tasks at different social interaction levels and correlated the results with individual memory outcomes in social interaction contexts. Results showed that after controlling for working memory level, only when a real speaker was present was listeners' SS-RIF significantly negatively correlated with their own RIF magnitude as speaker, while no relationships existed between other variables. This result does not match the experimental hypothesis.

According to Nigg' s (2000) classification and explanation of inhibitory control types, individual cognitive inhibition refers to the ability to intentionally suppress irrelevant information from working memory or attention, such as directed ignoring, directed forgetting, and negative priming paradigms. Therefore, some researchers believe that in individual retrieval practice paradigms, participants need to engage in directed selective retrieval tasks based on presented cues. In this selective retrieval, to retrieve target items more quickly and accurately, participants need to intentionally suppress other interfering competitive items (Anderson et al., 1994; Anderson & Levy, 2007). Accordingly, these researchers believe that the magnitude of individual RIF should be related to the ability to intentionally suppress irrelevant information—that is, higher cognitive inhibition ability should produce larger RIF effects in retrieval practice tasks. However, most of this research has used special populations (studies with elderly participants: Earles & Kersten, 2002; Zellner & Bäuml, 2006; Anderson, Reinholz, Kuhl, & Mayr, 2011; studies with PTSD patients: Foa, Feske, Murdock, Kozak, & McCarthy, 1991; McNally, Kaspi, Riemann, & Zeitlin, 1990). When using normal adults as participants to examine relationships between different inhibitory control tasks and individual RIF effects, Noreen and MacLeod's (2015) study found that individual RIF effects were not correlated with multiple inhibitory control tasks (including directed forgetting, Stroop, and Go/No-Go tasks).

The results of this experiment support Noreen and MacLeod's (2015) study, similarly finding that when individuals serve as speakers, their RIF is not correlated with multiple inhibitory control tasks. Furthermore, this experiment found that when individuals serve as listeners in interactive retrieval groups, their SS-RIF effects are also not correlated with these inhibitory control tasks. This result of no common variance among inhibitory control tasks has been extensively discussed in previous research (Chen, 2007). Researchers generally believe that any common inhibition ability may be altered by heterogeneous demands of specific tasks (Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Shilling, Chetwynd, & Rabbitt, 2002). Similarly, Experiment 2 found that SS-RIF is not correlated with variables from Nigg' s (2000) classification of inhibitory control types under different social interaction level conditions, suggesting that the inhibition process accompanying retrieval practice tasks differs from interference control, behavioral inhibition, and intentional cognitive inhibition.

Experiment 2 also found that in the real others' presence condition, listeners' SS-

RIF effects were significantly negatively correlated with their own RIF effects as speaker. This result suggests that in specific social interaction conditions, the two cognitive processes share some degree of similarity. Friedman and Miyake (2004), building on Nigg (2000), corresponded different types of inhibition to different information processing stages. According to this theory, speakers' inhibition of irrelevant competitive items in retrieval practice tasks is more likely to belong to pre-activation interference inhibition (Friedman & Miyake, 2004) —that is, a category of unintentional cognitive inhibition (incidental memory suppression). Similarly, in retrieval groups with real others' presence, when listeners carefully monitor the speaker' s selective retrieval activities, they are also affected by this unintentional inhibition of competitive items. Therefore, in individual-level analyses, the inhibition amounts produced by selective retrieval at the unintentional level are significantly correlated, and both are uncorrelated with the inhibition amount produced by intentional forgetting (directed forgetting) tasks, which explicitly instruct participants to intentionally suppress interfering information from memory. Experiment 2 provides important insights into how individual inhibitory control abilities influence and regulate memory retrieval performance in real interactive selective retrieval tasks.

However, one point requiring attention is that in Experiment 2' s real others' presence condition, the correlation between listeners' SS-RIF and their own RIF effects as speaker was significantly negative. The specific meaning of this behavioral negative correlation requires more attention from social cognitive neuroscience research. Based on this study, it is crucial to further explore how social interaction and individual difference factors interactively influence human memory and what the underlying neural basis might be. Humans are a social species, and the human brain has evolved in such a social environment (Dunbar & Shultz, 2007). Moreover, most human memory content is formed and preserved as individual memory in social interaction contexts (Csibra & Gergely, 2009). Therefore, to truly understand the macro-level problem of human memory, bottom-up social interaction factors and top-down inhibitory control factors are both crucial. Future research should consider observing and recording listeners' cognitive processing and measuring their neural basis in real-time during social interaction retrieval processes to examine how speakers'retrieval behaviors affect the cognitive processing and behavioral outcomes of listeners with different inhibition levels under different social interaction modes. This will have important guiding significance for understanding the basic laws of interpersonal social interaction in natural contexts and its potential clinical and educational applications (particularly in judicial and educational fields).

4 General Discussion

This study conducted two experiments to first examine, from a bottom-up perspective, the influence of the social contextual factor of others' presence on SS-RIF, and then further investigate, from a top-down perspective, how different inhibitory control factors affect SS-RIF under conditions of others' presence.

Experiment 1 showed that compared to the no real others' presence condition, only when a real speaker was present did listeners exhibit SS-RIF. This indicates that in memory retrieval groups with different social interaction levels, the occurrence of listeners' SS-RIF is conditional, particularly related to the processing of the bottom-up social contextual factor of whether the "other" (speaker) is physically present. Experiment 2 showed that in the real others' presence condition, SS-RIF effects were not correlated with interference control (Stroop task), intentional cognitive inhibition (directed forgetting paradigm), or behavioral inhibition (Stop Signal task) scores, but were only related to the magnitude of the individual' s own RIF effect as speaker. This result suggests that listeners' SS-RIF is similar to the occurrence process of RIF, both being related to the inhibition process of "effortfully" excluding competitive items from memory retrieval during interactive retrieval practice tasks. The study results suggest that in social interaction retrieval groups, there exist at least bottom-up processing of social contexts and top-down regulation from individual inhibitory control, with this bidirectional processing jointly influencing the occurrence of SS-RIF (see the bidirectional processing model in Figure 4 [Figure 4: see original paper]).

Figure 4 Bidirectional Processing Model of Socially Shared Retrieval-Induced Forgetting

Previous behavioral and individual cognitive neuroscience research suggested that as long as listeners carefully monitor the "speaker' s" retrieval content, SS-RIF should occur. That is, as long as listeners' participation level is high, they will automatically engage in "implicit retrieval" when listening to the speaker' s retrieval practice, subsequently showing SS-RIF, which has no direct or necessary relationship with whether a real speaker is present (Koppel & Storm, 2014; Coman, Coman & Hirst, 2013; Coman & Hirst, 2015). However, in Experiment 1 of this study, analysis of participants' teamwork tendencies, task involvement levels, and empathy quotients measured after the memory retrieval task showed that participants in different experimental conditions were all seriously involved in the interactive memory retrieval task with the "other," carefully monitoring the "speaker' s" retrieval results. Yet, in the no real speaker presence condition, even though listeners carefully monitored the "virtual speaker' s" retrieval content, SS-RIF did not stably occur. This suggests that "careful monitoring" is not a necessary condition for triggering listeners' "implicit retrieval," and thus not a necessary condition for SS-RIF occurrence.

Experiment 1 of this study found that others' presence as a social interaction level factor is crucial for SS-RIF. Previous social cognitive neuroscience research suggests that higher social interaction levels lead to greater similarity in neural activity processes between two individuals, and this higher neural activity similarity can predict better understanding and cooperative behavior between individuals (Jiang et al., 2012). This influence of different interaction levels on human cognitive processing has been repeatedly verified in brain imaging studies (Cui et al., 2012; Zheng et al., 2018). Furthermore, a recent study published in

Cell used Egyptian fruit bats as subjects to examine neural synchrony between two bats in real interactive contexts and its relationship with social interaction behavior. Results showed that neural synchrony between bat pairs in the same cage was higher than that between bats in different cages, and this increased neural synchrony remained even after controlling for biological rhythm factors. Moreover, bats' neural synchrony was significantly correlated with their social behavior (Zhang & Yartsev, 2019). This study indicates that the social interaction condition of other bats' presence affects bats' social cognitive behavior by modulating neural activity toward synchrony (see similar research in Kingsbury et al., 2019). Experiment 1 of this study verified relevant inferences from social cognitive neuroscience research, demonstrating in human subjects that the bottom-up processing of the social contextual factor of real speaker presence is crucial for listeners' memory retrieval performance.

To date, regarding the cognitive mechanism of SS-RIF, researchers generally speculate that it is similar to the retrieval inhibition hypothesis of speakers' RIF (Bai et al., 2016; Li, 2017; Abel & Bäuml, 2019). That is, in social interaction retrieval groups, only when listeners monitor the speaker' s retrieval activities in real-time and "implicitly" retrieve and practice target items (rather than simply "relearning" the speaker' s retrieval items; Jeroen & Raaijmakers, 2012) can they produce activation of target items and inhibition of competitive items, subsequently showing SS-RIF.

Therefore, to further examine the occurrence process of listeners' SS-RIF in social interaction retrieval groups, Experiment 2 of this study further explored the relationship between multiple inhibitory control tasks and RIF and SS-RIF scores under different social interaction level conditions. Results showed that under different social interaction level conditions, listeners' SS-RIF was not correlated with scores from individual-level interference control (Stroop task), intentional cognitive inhibition (directed forgetting paradigm), or behavioral inhibition (Stop Signal task). This result is similar to previous research and similarly questions the relationship between the inhibition process in RIF and other inhibitory control tasks, thereby questioning the similarity of inhibitory psychological processes triggered by different tasks (see similar research in Noreen & MacLeod, 2015; Shilling et al., 2002). Furthermore, in individual memory retrieval research, some studies have proposed dual-mechanism theories of individual RIF (Rupprecht & Bäuml, 2017; Schilling, Storm, & Anderson, 2014). For example, in retrieval practice tasks, inhibition mechanisms and blocking mechanisms function at different stages to affect speakers' RIF effects. That is, these studies suggest that memory retrieval inhibition processes are not only affected by retrieval inhibition, so individual-level inhibitory control variables are not significantly correlated with memory retrieval inhibition effect sizes. The results of Experiment 2 provide inspiration for the possible existence of dual-mechanism or even multi-mechanism theories of SS-RIF in social interaction contexts.

Experiment 2 of this study also found that in the real others' presence con-

dition, listeners' SS-RIF effects were correlated with their own RIF effects as speaker. This result supports that in social interaction selective groups, listeners' SS-RIF is related to the magnitude of their own individual RIF effects as speaker, indicating that the internal mechanisms of the two psychological processes share similarities. This is consistent with Abel and Bäuml' s (2019) recent research findings that the internal mechanisms of SS-RIF and individual RIF are similar, both being based on a certain degree of long-term inhibition of competitive items. Regarding this cognitive inhibition process for competitive items, Harnishfeger' s (1995) two-dimensional division theory of inhibitory control mentioned that inhibitory control has two cognitive levels: intentional and unintentional. Unintentional inhibition occurs before conscious awareness, while intentional inhibition occurs when stimuli are classified as irrelevant and individuals consciously suppress them (such as thought suppression and directed forgetting). Friedman and Miyake' s (2004) research also supplemented Nigg' s (2000) understanding of cognitive inhibition by exploring the unintentional category of cognitive inhibition—pre-activation interference inhibition (the ability to unintentionally exclude previously task-relevant memory information from intrusion). In the selective retrieval practice task of this study, speakers orally completed target items based on retrieval cues as quickly as possible, while listeners closed their eyes and carefully listened to the speakers' oral reports. For both, they had no explicit intention to forget competitive items; this cognitive inhibition of competitive items occurred more at the unconscious level. Therefore, the unintentional-level cognitive inhibition amounts produced by selective retrieval are significantly correlated, and both are uncorrelated with the cognitive inhibition amount produced by intentional forgetting (directed forgetting) tasks, which explicitly instruct participants to intentionally suppress interfering information from memory. Experiment 2 of this study provides important insights into how individual inhibitory control abilities influence and regulate memory retrieval performance in real interactive selective retrieval tasks.

However, one point requiring attention is that in Experiment 2' s real others' presence condition, the correlation between listeners' SS-RIF and their own RIF effects as speaker was significantly negative. The specific meaning of this behavioral negative correlation requires more attention from social cognitive neuroscience research. Based on this study, it is crucial to further explore how social interaction and individual difference factors interactively influence human memory and what the underlying neural basis might be. Humans are a social species, and the human brain has evolved in such a social environment (Dunbar & Shultz, 2007). Moreover, most human memory content is formed and preserved as individual memory in social interaction contexts (Csibra & Gergely, 2009). Therefore, to truly understand the macro-level problem of human memory, bottom-up social interaction factors and top-down inhibitory control factors are both crucial. Future research should consider observing and recording listeners' cognitive processing and measuring their neural basis in real-time during social interaction retrieval processes to examine how speakers'retrieval behaviors affect the cognitive processing and behavioral outcomes of listeners with differ-

ent inhibition levels under different social interaction modes. This will have important guiding significance for understanding the basic laws of interpersonal social interaction in natural contexts and its potential clinical and educational applications (particularly in judicial and educational fields).

5 Conclusion

The results of this study indicate that compared to social interaction levels without real others' presence, only when a real speaker is present do listeners exhibit SS-RIF. Furthermore, under real speaker presence conditions, listeners' SS-RIF is only related to the magnitude of their own RIF effects as speaker. The findings provide the first theoretical support for the joint influence of social interaction factors and individual factors on memory retrieval performance in social interaction contexts, offering important inspiration for future research using cognitive neuroscience methods in terms of research paradigms and approaches.

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Socially Shared Retrieval-Induced Forgetting in a Naturalistic Collaborative Retrieval Situation

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Abstract: In our daily life, people have plenty of opportunities to share their memories of past experience or knowledge with others. In such conversation, the phenomenon which, due to conscious or unconscious selective retrieval of speakers, listeners forget the unmentioned but relevant memories, is called socially shared retrieval-induced forgetting (SS-RIF). Based on previous research of the phenomenon, the current study focuses on the influence of bottom-up processing of social interactive situations and top-down cognitive control of inhibition on SS-RIF, investigating whether the presence of speaker or not, and the listener' s ability of various types of inhibition control would affect the occurrence and scale of SS-RIF.

In Experiment 1, a 2 (interactive level: the presence of the speaker, the absence of the speaker) × 2 (interactive role: speaker, listener) × 4 (item types: Rp+, Rp-, Nrp+, Nrp-) mixed design was adopted, in which interactive level was the between-participants design while interactive role and item type were the within-participants design. The dependent variable was the correct recall proportion in the final recall test. A total of 116 healthy volunteers participated in Experiment 1. They were randomly assigned to different interactive level conditions. All participants of Experiment 1 were recruited in Experiment 2 to explore the effect of different types of inhibitory control on socially shared retrieval-induced forgetting in different experimental conditions.

It was found in Experiment 1 that, regardless of condition, the phenomenon of within-individual retrieval-induced forgetting in speakers appeared; however,

the socially shared retrieval-induced forgetting in listeners only arose in the presence of the speaker condition. Furthermore, Experiment 2, carried out on the basis of Experiment 1, showed that the effect of socially shared retrieval-induced forgetting was independent from levels of inhibitory control. Interestingly, in the presence of the speaker condition, the effect of socially shared retrieval-induced forgetting in listeners was correlated with the effect of their within-individual retrieval-induced forgetting as speakers.

The above results indicate that the factor of social interactive situation indeed plays a significant role in the effect of SS-RIF. Without the presence of speaker, through monitoring the accuracy of audio material, listener' s SS-RIF do not appear. Moreover, the finding that levels of inhibition control do not affect SS-RIF may provide evidence for the double or multiple mechanisms under SS-RIF in social interactive condition, that is, not only inhibition, but also other mechanisms such as blocking jointly explain the phenomenon of SS-RIF. Furthermore, according to the correlation of the same person' s effect of socially shared retrieval-induced forgetting as listener and within-individual retrieval-induced forgetting as speaker, it can be speculated that the inner mechanism of SS-RIF and RIF shares certain similarities. These findings are of great significance for understanding the occurrence conditions and factors affecting socially shared retrieval-induced forgetting, and shed light on the bidirectional processing model of SS-RIF. Further, they contribute to the revelation of the important role of SS-RIF in listeners forming collective memory, and provide some inspiring viewpoints for future research.

Key words: socially shared retrieval-induced forgetting, presence of the speaker, inhibitory control, incidental memory suppression

Note: Figure translations are in progress. See original paper for figures.