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Department of Psychology

The Company We Keep: Social Group Membership as a Facilitator of Associative Inference in Factual Knowledge Acquisition

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Abstract

Social relationships and group membership shape cognitive functions, including memory. One memory function contributing to knowledge acquisition is the ability to draw novel conclusions by linking overlapping but distinct episodic memories, a process called associative inference. Prior research shows that both general memory and associative inference for arbitrary objects are enhanced when material is associated with a social ingroup (a group perceived as similar and likeable) rather than an outgroup.

Across two experiments (total $N = 95$), I examine whether this ingroup advantage extends to factual knowledge and whether it depends on an individual group member presenting the material or emerges from group-level associations alone. Experiment 1 tests whether associative inference across overlapping stimuli is better when facts are presented by an ingroup compared to outgroup persona. Experiment 2 asks whether this advantage persists when the material is tied to the group itself, rather than one specific individual.

I find strong evidence for a general ingroup advantage in associative inference, and tentative evidence that this advantage holds even without an individual persona as the source. The findings are discussed in terms of proposed mechanisms such as source monitoring and novelty perception, along with implications for future research and societal contexts.

Key words: episodic memory, associative inference, memory integration, social identity theory, semantic knowledge acquisition, social groups, source monitoring.

Thank You

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Introduction

Imagine you're walking in a park and see a woman walking a dog. A few days later, you see the same dog again, but now a man is walking it. Based on your observations, you might reasonably conclude that the woman and the man must know each other, even though you never saw them together. This example, drawn from Schlichting & Preston (2015), illustrates associative inference: the brain's ability to link separate events through a shared element, inferring relationships between elements that were never directly experienced together. This capacity for associative inference is not only cognitively but also socially relevant. In everyday life, both in person and online on social media, we constantly piece together information from different sources and conversations into a single knowledge base. Information is taken and connected to infer for example, who knows what, which topics are related or why someone may have done something. Here, *who* a piece of information comes from, might shape how readily it is integrated. Research consistently shows that people are more likely to accept and remember information linked to their own group (Jeon et al., 2021), and to incorporate misinformation from ingroup sources (Pennycook & Rand, 2021). This dynamic can be applied to increasing societal polarisation, where group identity acts as a filter on what we believe and remember (e.g., Jansson & Hattiangadi, 2025). Understanding how group membership influences memory integration is therefore not only a cognitive question, but also a relevant societal one. If people more readily integrate information from ingroup sources into their existing knowledge base, this could contribute to the formation of diverging factual realities in different social groups, a mechanism that may further reinforce polarisation.

This thesis took an interdisciplinary approach to strengthen the body of research on social influences in episodic memory integration. The overarching aim of the two experiments was to investigate whether associative inference is facilitated when memories are linked to members of a liked or self-identified social group. Experiment 1 aimed to extend the findings of Boeltzig et al. (2023) that associative inference is stronger for ingroup compared to outgroup sources, to a more ecologically valid setting. Specifically, Experiment 1 used factual knowledge sentences as stimuli and a cued recall paradigm following Varga & Bauer (2017). This broadened the methodological scope and applicability of the effect beyond the original paradigm which used arbitrary object stimuli. However, because Experiment 1 presented information from a single group member throughout, it left open the question of whether any observed facilitation reflected group membership per se, or simply the influence of one consistent individual source. Experiment 2 addressed this limitation directly by introducing a manipulation: the information required for associative inference was now presented by two different individuals who both belonged to the same social group. This design allowed for a direct test of whether any ingroup facilitation effect was truly driven by shared group membership rather than by the influence of a single, consistent source. In doing so, Experiment 2 theoretically investigated whether group membership enables different individuals to function as interchangeable links in memory, and which aspects of group identity and perceived groupness underlie this capacity.

Theoretical Background

Basic Concepts in Memory Research

Memory is the system that encodes, stores and reconstructs our experiences and information from the world around us (Glenberg, 1997; McDermott & Roediger III, 2025). It supports identity, decision-making and social interactions and is grounded in neural mechanisms while it is also shaped by culture and social communication (Sridhar et al., 2023). Episodic memory is the memory of events one has personally experienced, often tied to a specific time and place (Tulving, 1985). It is closely tied to autonoetic consciousness, the self-awareness that allows one to mentally travel in time to past experiences and future imagined events (Suddendorf et al., 2009). Episodic memory is context dependent (e.g., Staudigl & Hanslmayr, 2013), organised by event boundaries (e.g., Jeunehomme & D'Argembeau, 2020) and captures multimodal experiences including their spatiotemporal context (Spens & Burgess, 2024).

The key processes in the creation of long-term memories are encoding, storage and retrieval. Encoding is the initial step of perceiving information. It is constrained by attentional and perceptual capacities as well as task-related factors. Storage refers to memory traces created through consolidation, which integrates and stabilises information into long-term memory. Retrieval is the process of reactivating stored memories to consciously access them, often relying on external or internal cues (McDermott & Roediger III, 2025; Sridhar et al., 2023). On a neural level, episodic memories are encoded through hippocampal activation during an experience, with novelty playing a key role: the more novel the stimulus, the more strongly the hippocampal formation is engaged during encoding (Spens & Burgess, 2024). When a memory is later recalled, it is retrieved through the reactivation of neural patterns that were active at the time of encoding, a process called cortical reinstatement (Danker et al., 2016).

But memories are not exact replays of the past. Instead, they are characterised by imperfections, which already Schacter (1999) described as the 'sins of memory': Memory is biased, suggestible, changed by forgetting and altered or distorted by events post encoding. A memory of a conversation with a friend for example can change, if the friendship breaks and the emotion towards the person changes. Importantly, however, memory's reconstructive nature is not just a design flaw. The same flexible system that makes memory fallible is also what equips it to simulate future events: past experiences can be recombined and used to guide behaviour in novel situations (Fenneman et al., 2025).

This constructive flexibility is assumed to be implemented through reconsolidation. When a consolidated memory is reactivated, for example to be retrieved, it re-enters a state susceptible to change before it is re-stabilised (Hupbach et al., 2013). During this window, the memory trace can be updated, strengthened or weakened by the information present at the time of retrieval (Cotton & Ricker, 2022). Reconsolidation through cortical reinstatement thus provides one mechanism necessary to adaptively exist in a changing environment.

Memory and Knowledge Integration

Experience is organised in episodic events. Between sitting in a café and walking home, a change of context allows the brain to store the two separately. Event boundaries help organise the past and present into discrete episodic memories (Laing & Dunsmoor, 2025). But sometimes independently experienced events need to be combined to interact and plan appropriately. Take the dog in the park: the brain must combine two individual experiences based on an overlapping element (the dog) to connect the two independent elements (the woman and the man). *Memory integration* across episodes is the process by which new information is connected to pre-existing episodes, knowledge structures, or schemata (Sridhar et al., 2023) and serves multiple purposes: planning, generalising, deriving abstract structures, and constructing a general knowledge base (Varga & Bauer, 2017). For instance, the semantic knowledge system self-derives much of its content through the integration of information that was learned in separate yet related episodes. This way, some semantic memories have no episodic "counterpart", because they were never directly experienced (Bauer & Jackson, 2015). The flexible recombination of episodic memories is a key mechanism through which new semantic knowledge is formed (Bauer et al., 2020).

Memory integration as the process of linking overlapping experiences into a unified mental network yields important cognitive outcomes. Amongst others, it allows concept acquisition (learning general categories form specific examples) (e.g., Margolis & Laurence, 2011), helps spatial and conceptual navigation by building internal cognitive maps (Morton et al., 2017), and enables the deduction of logical relationships between items (transitive inference) (e.g., Acuna et al., 2002). Another outcome of memory integration is associative inference (e.g., Liu et al., 2024). While memory integration broadly links related information from separate events into a comprehensive mental model, associative inference is the specific ability to use those integrated memories to infer relationships between items that were never directly experienced. This ability is commonly tested using the *associative inference task* (Zeithamova et al., 2012; Zeithamova & Preston, 2010). In the standard paradigm, participants learn associations between stimuli AB and BC, oftentimes in one-trial learning (Varga & Bauer, 2017) and are then tested on the unobserved but inferrable AC association. A body of research has applied this paradigm to explore self-derivation of factual knowledge (Bauer & Jackson, 2015; Varga & Bauer, 2017), using novel factual sentences rather than arbitrary pairs of objects as stimuli. Varga and Bauer (2017) demonstrated that the self-derivation of factual knowledge is indeed a result of memory integration mechanisms. Young adults were presented with novel sentences (e.g., *Octopus blood contains copper*. And *Blood that contains copper is blue*.) without being informed about their relational (AB and BC) structure. In a cued recall test, participants could self-derive the AC association (*Octopus blood is blue*.) in approximately 50% of the trials. Their findings suggest that memory integration is a powerful mechanism for semantic knowledge acquisition with substantial individual variability.

Source Memory

Source memory is a distinct concept from item memory that concerns perceptual attributes tied to the origin of a memory, such as the identity of a speaker, the colour of a stimulus, or feelings during encoding (Pereira et al., 2023). During encoding, the hippocampus binds item and source information together (Yonelinas et al., 2019). The *source monitoring framework* (Johnson et al., 1993; Lindsay & Johnson, 2000) proposes that the accuracy of a source memory is shaped by previous knowledge, beliefs and stereotypes, but also perceptual features of the event. Research has connected source memory to memory inference performance, though findings are mixed. Carpenter & Schacter (2018a, 2018b) found that successful inference reduced source memory accuracy. This indicates a trade-off between integration and preservation of event-specific details. Meanwhile, other studies found no such connection (e.g., Boeltzig et al., 2023; De Araujo Sanchez & Zeithamova, 2023) and Liu et al. (2026) even reported a positive association in the behavioural outcomes: Participants who accurately retrieved AC associations based on naturalistic stimuli also showed higher source memory accuracy and confidence. These inconsistencies warrant further investigation.

Social Cognition and Intergroup Processes

Humans are social creatures. To survive, we need to collaborate, communicate, and learn from each other's experiences (Leblanc & Ramirez, 2020). Very naturally and often automatically, we categorise people around us into social groups, which helps to organise knowledge about potential collaborators and opponents and produces expectations to guide interactions (Liberman et al., 2017). *Social identity theory* (Tajfel & Turner, 1979) proposes that individuals derive a significant part of their self-esteem from their membership in social groups, inspiring them to categorise the world into ingroups and outgroups. To maintain a positive self-image, people are inclined to view their own groups as superior. A vast catalogue of studies shows that within social groups, people tend to like and trust their ingroup members more (M. Brewer, 1999), favour them in resource allocation (Chae et al., 2022) and cooperate with them more readily (Balliet et al., 2014). Outgroup members on the other hand, tend to be associated with negative attributes, such as being less trustworthy (M. Brewer, 1999; Stanley et al., 2011) and are often regarded with prejudice (Borinca et al., 2023). Interestingly, ingroup favouritism has been associated with a preference for the ingroup more strongly than a disliking of the outgroup (Balliet et al., 2014) and seems to be reinforced in conditions of resource scarcity (Chae et al., 2022). Both ingroup favouritism and outgroup discrimination can even be found in minimal experimental groups (Tajfel, 1970, 1974), an experimental paradigm that bases group allocation on an arbitrary or meaningless criteria like preference for abstract art or flipping a coin and was designed to keep groups independent of any social categories or stereotypes (Eckel et al., 2022).

Social Influences on Memory

Social groups and relationships affect learning and memory (De Felice et al., 2023). Evolutionarily, humans are able to learn skills more efficiently through social imitation than by trial and error (Leblanc & Ramirez, 2020). Beyond skill acquisition, social interaction also shapes how memories are formed and maintained. During conversations with others, memories are reactivated and can be altered (Nadel et al., 2012), a process that can also underly the emergence of collective memory. Collective memory is the shared understanding of a group's past that influences the group's identity and sense of agency (Fischer & O'Mara, 2022). Within groups, information is reinforced if it aligns with the group views (Jost et al., 2022), and a collective memory in turn provides schemata that facilitate recall, guide behaviour and worldviews of group members, and allow communities to learn from the past and imagine their futures (Fischer & O'Mara, 2022). Humans are thus highly motivated to create and maintain shared realities with their ingroups (e.g., Hogg & Rinella, 2018).

One mechanism through which social interaction shapes memory is *social contagion*, which is the process of memories spreading from one person to another through social interaction (Roediger et al., 2001). An extensive body of eye-witness research beginning with Loftus and colleagues in the 1970s (Hirst & Echterhoff, 2012; Powers et al., 1979) has demonstrated that hearing another person describe an event can alter one's own memory and induce false memories, as elements mentioned by the speaker are incorporated (Andrews & Rapp, 2014; Harris et al., 2017). Social contagion is often attributed to source monitoring failures, where the origin of a memory cannot be accurately recalled and is misattributed to one's own experience (Hirst & Echterhoff, 2012). Several factors amplify the social contagion effect: familiarity or romantic involvement with the conversation partner (French et al., 2008; Peker & Tekcan, 2009), liking them even if they are a stranger (Hope et al., 2008), higher perceived credibility and expertise (Andrews & Rapp, 2014; Echterhoff & Hirst, 2009), and a higher number of partners sharing the same altered version (Abel & Bäuml, 2023). These social factors are also reflected in the brain: proximity and familiarity lead to stronger synchronisation in the default mode network while a narrative is shared between two people (Menon, 2023).

Importantly, it is not only direct interaction that shapes memory. Group membership also biases what we remember. Experimental, minimal, and real-life groups all produce an *ingroup memory advantage*: memory for ingroup faces is better (Burgund, 2021; Tüttenberg & Wiese, 2023), information associated with the ingroup is remembered more accurately (Jeon et al., 2021) and processed more efficiently (Enock et al., 2018), even when that association is incidental. Complementing the factors discussed for social contagion, the ingroup memory advantage varies as a function of a person's identification with the ingroup and seems to be driven more by enriched encoding of ingroup information than by active suppression of outgroup material (Jeon et al., 2021).

Social contagion and ingroup memory advantage have been attributed to a shared mechanism: the credibility and perceived trustworthiness of the information source. Lower credibility is thought to increase source monitoring, which redirects attention toward the source person and, when resources are limited, away from the stimulus content. This can reduce the contagion effect and the encoding depth of the stimulus (Andrews & Rapp, 2014; De Martino et al., 2009). Boeltzig et al. (2023) applied this *resource allocation logic* to associative inference: if outgroup members are perceived as less credible, attentional resources are allocated toward monitoring them rather than encoding the stimulus content, which impairs memory integration. Consistent with this account, they found that participants drew novel AC inferences more accurately and more confidently when items were presented by an ingroup member of a self-formed group, compared to an outgroup member. This was the first demonstration of an *ingroup inference advantage* in an associative inference paradigm. A subsequent Bachelor's Thesis (De Sousa Mestre & Rygert, 2024) applying the paradigm to factual knowledge stimuli, found elevated false alarm rates for ingroup items (higher chance of accepting false information) but no ingroup advantage on inference, which left the robustness of the social group effect uncertain. Supporting the proposed resource allocation mechanism, Boeltzig et al. (2023) and later also De Sousa Mestre & Rygert (2024) found that source memory was better for outgroup sources, particularly in incorrect AC inference trials. This pattern suggests a differential prioritisation of resources during encoding: when encoding is difficult, attention shifts toward the memory content for ingroup sources, at the cost of source memory. For outgroup sources, monitoring remains consistent regardless of encoding difficulty, preserving source memory but potentially at the cost of deeper integration of the stimulus content (Boeltzig et al., 2023).

A short example to illustrate this would be that under normal circumstances, both the person who tells you something (source) and the information they tell you (item) are remembered. Then, as soon as the conditions become more demanding, the brain must prioritise if more resources go into encoding the source or the item. This prioritisation is proposed to be based on perceived trustworthiness and familiarity of the person, with more trust (e.g., because of ingroup membership) resulting in a focus on item encoding and more suspicion (outgroup membership) resulting in a focus on source monitoring.

Entitativity of Social Groups

Entitativity (Blanchard et al., 2020; Campbell, 1958) describes the perceived coherent unity of a social group (e.g., a sports team vs. four people waiting at a bus stop together) (Blanchard et al., 2023). This perceived "groupness" is consequential: high-entitativity groups elicit stronger emotional responses, exert greater influence on behaviour, and serve as more powerful anchors for social identity (Bertille, 2025; Lickel et al., 2000). Key predictors of entitativity include interactivity, similarity, and shared history (Blanchard et al., 2020, 2023). Additionally, perceiver variables such as processing goals, certainty orientation, and ingroup status moderate how entitative a group appears (M. B. Brewer et al., 1995).

In memory research, entitativity is an interesting concept because it shapes whether information is encoded at the group or individual level. High-entitativity groups tend to produce more category-based memory errors, where behaviours are misattributed between members, whereas low-entitativity groups support stronger person-specific memory (M. B. Brewer et al., 1995). Crawford et al. (2002) also showed that high entitativity prompts observers to form abstract group-level representations, making members cognitively substitutable for one another and fostering stereotypes. Members of low-entitativity groups by contrast, are processed as individuals and assigned more person-specific traits. However, Navon et al. (2026) found that when individuating information is diagnostic, it can override group-based processing even under conditions that favour categorical judgement.

The relationship between ingroup/outgroup status and entitativity is not fully settled. At first glance, the findings appear contradictory: ingroups tend to be perceived as more entitative, while outgroup members tend to be seen as more similar to one another. However, some findings suggest that similarity and entitativity may be conceptually distinct and have been operationalised as distinct concepts in research (Crump et al., 2010). At the encoding level, outgroup members tend to be processed categorically, while ingroup members are processed at both individual and category levels (M. B. Brewer et al., 1995). Taken together, the literature suggests that encoding level is a function of both entitativity and group membership, but the precise conditions under which each factor dominates remain unclear, and much of the relevant research appears outdated in its methodological standards.

Rationale and Hypotheses

The *ingroup inference advantage*, better associative inference across ingroup related events, was first established by Boeltzig et al. (2023) in two of their three studies, using arbitrary associations between objects. Given the novelty of the finding and its theoretical and societal relevance, conducting studies that strengthen the finding and extend its generalisability is an important next step, especially in the ongoing replication crisis in psychology (Shrout & Rodgers, 2018). A Bachelor’s thesis attempted this using factual knowledge stimuli but failed to reproduce the ingroup inference advantage (De Sousa Mestre & Rygert, 2024), leaving the robustness of the effect an open question. Instead, they found an increased number of false alarms for ingroup sources, where participants were more likely to accept falsely inferred AC statements from ingroup members. However, their study had an overall low memory discrimination rate in a 2AFC format. Whether interference rather than genuine integration may have driven the null result remains thus unclear. A question that an open recall format can address by eliminating guessing.

Using more naturalistic stimuli remains a meaningful next step, as Varga & Bauer (2017) had previously demonstrated that factual sentences can be connected into novel inferences by participants, and because facts are more relevant to real-world knowledge acquisition than the arbitrary object-background pairs used in earlier work (Boeltzig et al., 2023). Beyond stimulus type, the original paradigm leaves open other questions about the boundary conditions under which, if at all, the ingroup inference advantage effect can be found. The present thesis addresses both methodological and theoretical shortcomings across two studies.

One unresolved methodological question concerns the retrieval format. Both Boeltzig et al. (2023) and De Sousa Mestre & Rygert (2024) used a two-alternative forced choice recognition task, rather than the cued recall format applied by Varga & Bauer (2017). An open or cued recall format may be more appropriate for language-based stimuli to eliminate guessing, prevent ceiling effects and measure true inference more conservatively. A further open question concerns generalisability across populations. Boeltzig et al. (2023) recruited US-American participants and primed them with their political party affiliation before forming study ingroups and outgroups. The US two-party system is characterised by high levels of partisan polarisation and strong affective identification with political parties (Jost et al., 2022; Mason, 2018). The group manipulation likely activated deeply anchored and emotional identities. Whether the effect generalises to countries with multiple party democracies and without priming for polarised partisanship in the experiment, remains unknown. Given that ingroup-biased memory integration could be a meaningful contributor to the formation and maintenance of polarised belief systems, the generalisability of the effect is socially and politically relevant and investigation attempts remain worthwhile. Experiment 1 of this thesis addresses these questions by using cued recall with factual knowledge stimuli in a European sample, extending the original paradigm to a broader population and more naturalistic stimuli.

I expect that ingroup sources, compared to outgroup sources, will improve inference of novel associations across events.

Confidence can be an additional indicator of an ingroup effect on inference performance. The study that first discovered the advantage for ingroup sources in the associative inference task (Boeltzig et al., 2023) also found that ingroup sources predicted higher confidence in correct inference answers. In the present study, inference accuracy is the main measure of inference performance and confidence is consulted as a second measure. An ingroup advantage is expected to show up in both inference accuracy and confidence.

A second, theoretically important boundary condition concerns the role of the individual source. Boeltzig et al. (2023) failed to find the ingroup inference advantage in their second experiment, which used only one group member per ingroup and outgroup. This raises the question of whether the effect requires a felt sense of groupness, for example through high entitativity, rather than merely an individual associated with a group label. Experiment 2 of this thesis addresses this directly by presenting each of the two events that must be integrated by two different members of the same group. If participants can nonetheless draw novel inferences across these overlapping events, this would suggest that group membership itself, rather than a consistent individual source, drives the facilitation effect.

I expect that participants will be able to draw novel inferences when the two events are presented by two different personas from the same social group, and that an ingroup advantage will persist under these conditions.

Comparing performance across Experiment 1 and 2 further allows an exploratory test of whether group members function as interchangeable elements in the integration process. Theoretically based on the concept of entitativity, if group members are mentally represented as substitutable instances of their group rather than as distinct individuals, information presented by different members of the same group should be encoded as if coming from a single source, and inference performance should be equivalent across the two studies. If, on the other hand, individual-level encoding plays a larger role, integration across two distinct source personas would be expected to be more difficult, and performance should be weaker in Experiment 2 than in Experiment 1. Given the limited prior evidence and the theoretical complexity outlined above, this comparison is treated as an exploratory research question:

Does presentation condition (same individual vs. two group members) moderate the ingroup inference advantage, and if so, in which direction?

As described, the current state of research on how source monitoring and source memory are connected to associative processes, is ambiguous. Carpenter & Schacter (2018a, 2018b) found that successful inference led to systematic source misattribution, which frames source memory errors as a byproduct of the flexible recombination process underlying inference. This supports a trade-off account. In contrast, Liu et al. (2026) reported a positive behavioural association between inference accuracy and source memory confidence, though their neural findings were more complex: integration patterns predicted successful inference but reduced source memory, while separation patterns predicted the opposite. Within the social groups and inference literature specifically, findings are also inconsistent. Boeltzig et al. (2023) found better source memory for outgroup sources overall, with ingroup source memory declining under incorrect inference trials and more difficult encoding conditions, while outgroup source memory remains stable throughout. This is consistent with the source monitoring *resource allocation account*. De Sousa Mestre & Rygert (2024), however, found better source memory for ingroup sources, alongside higher false alarm rates for ingroup items. This suggests greater trust rather than reduced monitoring. Whether better ingroup inference is always accompanied by worse ingroup source memory remains an open question. Varying operationalisations of source memory across these studies and differences in used stimuli and reward systems may all attenuate or reinforce the effect. The present experiment provides the opportunity to extend the research on both the relationship between source memory and associative inference, and the proposed theory connecting outgroup interactions to increased source monitoring and reduced associative inference performance. The hypotheses are based on Boeltzig et al.'s (2023) findings:

I expect source memory to be better for correctly inferred trials than incorrectly inferred trials. In incorrectly inferred trials, I further expect outgroup source memory to be better than ingroup source memory.

Method

The hypotheses were tested in two online experiments collecting behavioural data on memory integration and social group influences.

Ethical Considerations

All participants provided informed consent. Data was collected and stored in accordance with the GDPR regulations and no data was entered into generative AI tools. Participation was voluntary, and participants could contact the researcher and withdraw their participation at any time. Compensation was offered via course credits or entry into a raffle for gift vouchers (100 SEK). Experimental data could not be connected to the identity of individuals and no data on ethnicity was collected. As specified in the rules of the Swedish Ethical Review Authority (Etikprövnings Myndigheten, 2023), the experiments did not require ethical approval: they did not collect sensitive personal data, use methods that involve a physical intervention, use methods that pose a risk of mental or physical harm, or study biological material taken from a living or dead human that can be traced back to that person.

Participants

Experiment 1

A small pilot study with six participants was conducted to ensure appropriate task difficulty (performance at ~75%) and clarity of instructions. An ideal sample size of 68 was estimated based on a power analysis in a previous study (Boeltzig et al., 2023). Because of the short time frame for the thesis project and because previous research had successfully applied associative inference paradigms with $N = 30$ participants (Carpenter & Schacter, 2018a; Varga & Bauer, 2017) and investigated social influences on memory processes with $N = 50$ participants (Jeon et al., 2021; Xia et al., 2019), a minimal sample size of 60 was determined. 63 participants were recruited via personal contacts and the University of Münster research pool. Data collection took place between February and March 2026. Six datasets were excluded because they were incomplete and another six participants were excluded based on predefined exclusion criteria (see *Data Preparation and Exclusion Criteria*). The final sample consisted of $N = 51$ participants (72.5% female, 23.5% male, 4% non-binary) with a mean age of 23.75 years ($SD = 3.51$, range: 18 to 35). The majority (98%) had finished high-school and 52.9% university. Inclusion criteria were age between 18 and 35 years, sufficient English proficiency to understand and memorise sentences, normal or corrected-to-normal vision, and access to a computer with a physical keyboard. Most participants (98%) were non-native English speakers.

Experiment 2

Based on the same inclusion criteria as in Experiment 1, a second sample of $N = 47$ was collected. Because of a short timeframe for data collection before the thesis deadline, and because the datasets could be combined with the data from Experiment 1, a smaller sample size was deemed acceptable with a cautious interpretation. Data collection took place in April 2026; recruitment strategies and compensation were the same as for Experiment 1. One dataset was excluded because of insufficient answering behaviour during the encoding phase, which was counted as a lack of engagement. Two datasets were excluded because they were incomplete. The final sample consisted of $N = 44$ participants (84.1% female, 15.9% male) with a mean age of 22.84 years ($SD = 2.64$, range: 18 to 30). The majority (68.2%) had finished high-school and 31.8% a university degree, no participant had English as a native language. Participants were not eligible for Experiment 2 if they had participated in

Experiment 1, which they had to confirm before participation. The final combined dataset of Experiment 1 and Experiment 2 included $N = 95$ participants (77.9% female, 20% male, 2.2% non-binary; age $M = 23.3$ years).

Design

Experiment 1

The experiment used a within-subjects design to examine the effect that the social group membership (ingroup vs. outgroup) of a person presenting pieces of information has on associative inference performance. The primary dependent variable was accuracy on associative inference trials. Secondary dependent variables included source memory accuracy (recognition of the persona or group that had previously presented a piece of information) and confidence ratings of inference responses. The primary independent variable was social group (ingroup vs. outgroup) of an information source. Moderator and secondary independent variables included perceived novelty of a presented fact and ingroup-outgroup liking difference.

Experiment 2

The experiment used the same design approach as Experiment 1 and the same dependent and independent variables with the difference that source memory accuracy was only assessed on the group level, not the persona level.

Comparison of the two Experiments

A between-subjects design was used to compare the difference in strength of the *ingroup inference advantage* between the experimental conditions: same source persona (Experiment 1) and different source personas (Experiment 2) presenting the corresponding stimuli AB and BC. The primary independent variable was experiment ID (Experiment 1 vs. 2), and the primary dependent variables were inference accuracy (main effect of experiment) and social group effect on inference accuracy (moderator effect of condition on ingroup effect).

Materials

Materials and stimuli were the same in Experiment 1 and 2.

Social Group Manipulation

Participants constructed an ingroup and an outgroup by selecting two teammates and two opponents from a set of eight female faces (Face Research Lab London Set; DeBruine & Jones, 2021, see Figure 1). Each group was assigned a colour by the participant which was displayed as a frame around the faces throughout the experiment (see Figures 2 and 3). Participants then further characterised each group by assigning attributes across six categories (political orientation, study major, eating habits, music preference, sports, and hobbies) to both groups. Each category had five options as attributes (see Appendix) and the same option could not be chosen for both groups. This group manipulation had previously been successfully used in the study by Boeltzig et al. (2023). I chose to reuse it to not introduce group manipulation as a potential confounding variable to the expected effects.

Memory Task Stimuli

The memory task consisted of 36 triplets of factual statements adapted from previous associative inference paradigms (De Sousa Mestre & Rygert, 2024; Varga & Bauer, 2017). Each triplet included an AB and a BC statement sharing a common element (B), allowing for the inference of an AC relationship. All statements were designed to be novel and covered nature- and science-related topics (see Table 1).

Liking Measure

The group liking was assessed using a five-item Likert scale (1 = not at all true, 7 = definitely true) developed by Veksler & Eden (2017) and previously successfully used in Boeltzig et al. (2023). Items measured participants' attitudes toward ingroup and outgroup members (e.g., "I would like to get to know these people better."; see Appendix).

Figure 1

Exemplary Set of Personas for Group Formation

Note. Participants chose their two teammates and two opponents from a set of eight faces.

Table 1

Statements used in the Memory Task

Pairs of AB and BC Statements	AC Statement	AC Recall Cue
(AB) Azizia is the hottest city in the world. (BC) The hottest city in the world is in Libya.	The city of Azizia is in Libya	Aziza is a city in …
(AB) Apple seeds are called pips. (BC) Pips contain cyanide.	Apple seeds contain cyanide.	Apple seeds contain …

Note. Two examples for statements used in the associative inference task.

Procedure

Experiment 1

The experiment was conducted online. It was created in PsychoPy (Peirce et al., 2019) and hosted on Pavlovia (Open Science Tools, Nottingham UK). Participants were asked to participate on a computer or tablet with a physical keyboard. For a smooth run, all stimulus material was downloaded before the start of the experiment. After providing informed consent and demographic information, participants completed the group formation task and an initial liking assessment of both groups. The memory task consisted of three encoding blocks and three recall blocks in alternating order. At the end, participants answered the liking measure a second time, indicated their effort (7-point scale) during the experiment, and recalled which personas belonged to which group, a failure of which led to exclusion from that dataset.

As a cover story, participants were told, they would participate in a memory game together with other participants who had chosen the same team members and against other participants who had chosen their opponents as team members. Participants were told that team members and opponents would present statements about various topics and were instructed to remember both the statements and who had presented it. Crucially, they were not informed of the relational structure of the data. During the recall task, participants were instructed to complete the presented sentences based on the information they had just learned, there was no explicit instruction to integrate statements.

In each encoding trial, participants saw a factual statement presented by a persona (ingroup or outgroup; see Figure 2 A). Statements were presented for seven seconds, followed by a novelty rating (scale 1-5, maximum response time = 4s). Each block included 24 encoding trials (12 AB and 12 BC statements). Corresponding AB and BC statements were always presented by the same persona and separated by two to four intervening trials (see Figure 3). While following this rule, trial order was randomised.

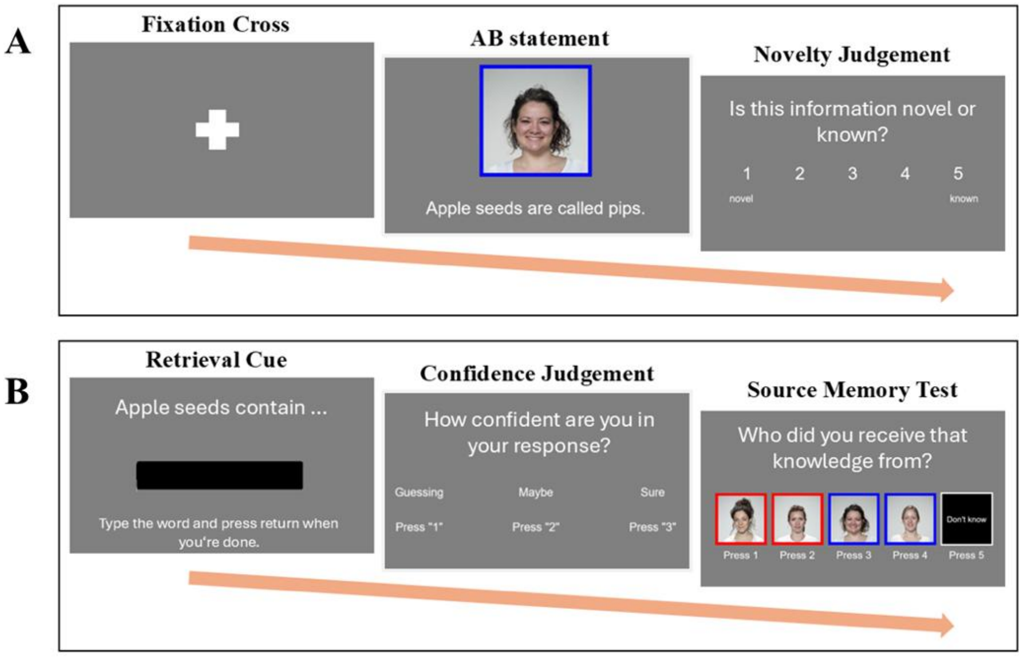
Each retrieval block included 12 cued recall trials assessing AC inference. Participants were presented a cue (A) and asked to type the corresponding C element (see Figure 2B and Table 1). Responses were self-paced. After each response, participants rated their confidence of the given answer (1 = guessing to 3 = sure) and indicated which of the four personas had presented the relevant information.

Experiment 2

Procedure in Experiment 2 was the same as in Experiment 1 with the only difference that corresponding AB and BC statements during encoding were always presented by two different personas of the same team (ingroup or outgroup; see Figure 3) and during retrieval, the two personas per team were grouped together as one response option respectively.

Figure 2

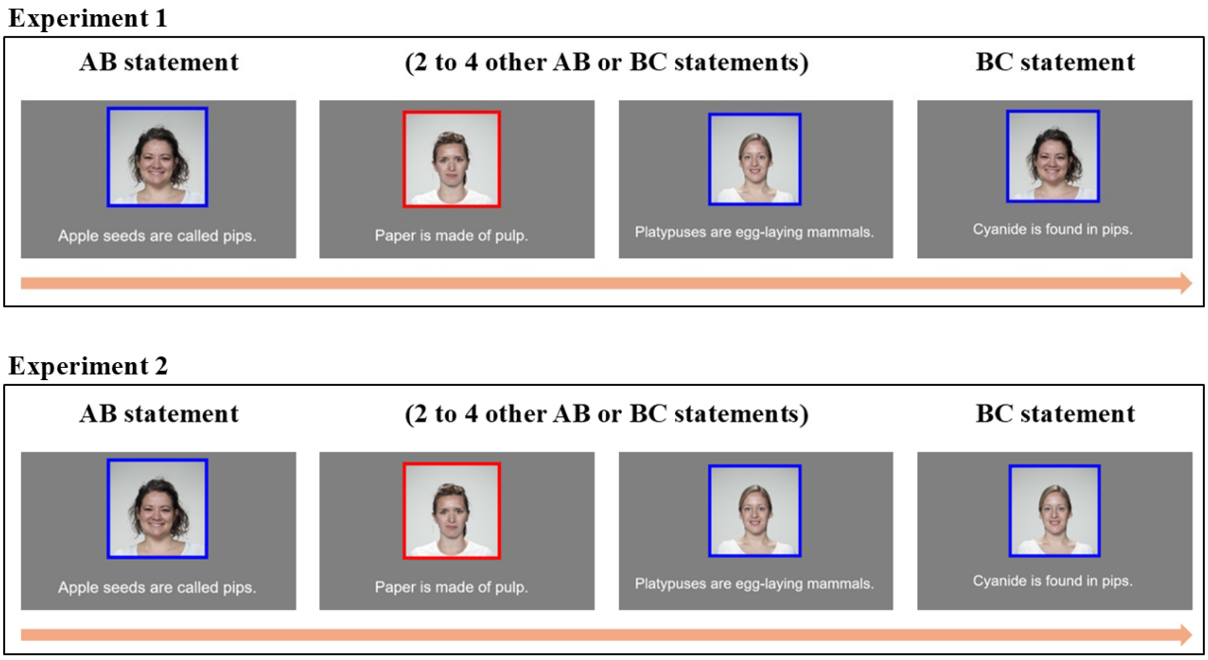
Encoding and Retrieval Trials in Experiment 1



Note. (A) Encoding trials included a fixation cross, a presentation of a statement and persona, and a novelty judgement task. (B) Retrieval trials included an associative inference task, a confidence judgement, and a source memory task (with five answer options in Exp.1 and three in Exp. 2, each including an "I don't know"-option, scored as missing response).

Figure 3

Procedure during Encoding



Note. Each pair of encoding facts (AB and BC) had two to four other statements in between its halves in the encoding phase. In Experiment 1, the corresponding AB and BC statements were presented by the same persona. In Experiment 2, the corresponding AB and BC statements were presented by the two personas within one team.

Data Analysis

Typed responses were manually scored according to predefined rules (see Appendix) in accordance with multiple researchers. Responses containing the correct target or acceptable synonyms were coded as correct. Responses in other languages than English or responses that contained both the combining (B) and the target (C) element were excluded. This led to an exclusion of 19 trials (1.03%) from the final dataset of Experiment 1 and eight trials (0.51%) from Experiment 2.

Data Preparation and Exclusion Criteria

Participants' responses were included in the analysis when meeting the following criteria: (1) Higher liking ratings for the ingroup than outgroup pre-memory task (manipulation check); (2) Self-reported effort > 2 on a 7-point scale; (3) Novelty responses to at least 90% of encoding trials (responsiveness check); (4) Associative inference accuracy within the predefined cut-offs of +/- 2 *SD* around the sample mean; (5) At least one correct and one incorrect AC trial per group condition to allow variance-based analyses. For source memory analyses, additional participants were excluded if they did not have at least one correct and incorrect source memory trial per group condition, a requirement for variance-based analyses. The cutoffs for inference accuracy were a priori defined as +/-2 *SD* around the sample mean, as extremely low performance may indicate failure to concentrate or engage with the task, and extremely high performance that the task lacked sensitivity for those individuals.

Due to the cued-recall format, response times of the inference task were not formally included as a dependent variable in any analysis. In Experiment 1, the response times had a median of 7.33 seconds (M = 10.0, SD = 9.22, min = 0.11, max = 117.36) for all trials and a median of 6.20 seconds for correct trials only (M = 8.23, SD = 7.35, min = 2.02, max = 79.36). Experiment 2 had a median response time of 7.85 seconds for all trials (M = 10.3, SD = 8.43, min = 2.08, max = 119.12) and a median of 6.39 seconds for correct trials (M = 8.55, SD = 6.80, min = 2.16, max = 57.0). Boxplots and outliers were examined for each participant as an additional indication of engagement, which was considered acceptable for all.

Statistical Analysis

All data from both experiments was processed and analysed in R-Studio (R Studio Team, 2019) using version 4.5.2 of R (R Core Team, 2025). The experiments were preregistered within the thesis course. Linear mixed effects models (LMM, for continuous, normally distributed outcome variables) and generalised linear mixed effects models (GLMM, for binomially or otherwise distributed outcome data) were fitted to the data, using the *lme4* (Bates et al., 2015) and *lmerTest* (Kuznetsova et al., 2017) packages, with REML (restricted maximum likelihood) estimation and Laplace approximation. LMMs were chosen over models such as ANOVAs to account for the non-independence of repeated measures within participants and stimuli. Additionally, LMMs robustly handle missing data and unbalanced sample sizes and allow inclusion of random effects.

Fixed effects of predictors and moderators were compared to $\alpha = 5\%$ significance levels with 95% Wald approximated confidence intervals. Effect sizes are reported as odds ratios (OR), obtained by exponentiating the log-odds estimates of the models for the GLMMs and Cohen's d for the LMMs. No correction for multiple comparisons was applied, as the analyses were hypothesis driven.

To check if the manipulation of the groups worked, paired samples t-tests were calculated to compare liking measures for each participant between ingroup (team) and outgroup (opponents) before the experiments. Significantly stronger liking of the ingroup than outgroup indicates successful manipulation. Additionally, as the statements were intended to be novel learning material, *perceived novelty at encoding* was compared between AB and BC statements using paired t-tests and compared between social groups using an LMM. For all t-tests, the required normal sampling distribution of the mean was assumed based on the central limit theorem ($N > 30$).

The following analyses were calculated to test the hypotheses: To test whether ingroup presentation facilitated associative inference, accuracy and confidence of inference answers were modelled as dependent variables. A GLMM with a binomial distribution and logit link function predicting inference accuracy (binary response with 0 = false, 1 = correct per trial) from *social group* (ingroup vs. outgroup presentation) was fitted to the data. *Block number* was included as a covariate to control for differences between blocks, as the experiments did not have a practise phase before block 1 and a learning effect was expected, and *participant ID* and *fact number* were included as random intercepts to account for stable differences between individuals or stimuli items in for example difficulty. Random slopes for *social group* by *participant* were not included, as *social group* was the primary fixed effect of interest and allowing it to vary across participants would partial out the variance the analysis aimed to explain. An LMM predicting confidence (scale 1-3) in correctly answered inference trials, as a second measure of inference performance, included the same fixed and random effects. Both models were fitted to the data of Experiment 1 and 2 separately, to test the main effect of *social group* respectively and investigate if it persisted under the conditions of Experiment 2.

To compare the inference accuracy and the magnitude of the *social group* effect between the two experimental conditions, a GLMM predicting inference accuracy was fitted to the combined dataset. *Experiment ID* (Experiment 1 vs. 2) was the independent variable of interest. It was added as a between-subjects predictor to compare the two experimental conditions, and as an interaction with *social group* to check if it moderated the *social group* effect. *Block number*, *participant ID* and *fact number* were included in the same way as above.

Perceived *novelty* of the presented statements at encoding was modelled in an LMM to investigate social group differences. And, as an additional robustness check, because it can reasonably influence inference accuracy, novelty was included as a predictor and moderator (interaction with the social group main effect) in the GLMMs predicting associative inference accuracy to investigate moderation effects of statement novelty on the ingroup inference advantage.

To investigate source memory, the memory for the persona or team that had presented the statements at encoding, *team source memory* (Experiments 1 and 2) and *persona source memory* (Experiment 1) were modelled in separate GLMMs as dependent variables (binary scoring of correct/false responses in models with a binomial distribution and logit link function). The main effect of *inference accuracy* while controlling for *block number* and *participant ID* tested whether source memory was better in correctly inferred trials. The interaction of *social group* and *inference accuracy*, combined with post-hoc analyses on subsets of the data (e.g., just incorrect trials), were used to investigate if outgroup source memory was better in incorrect inference trials, as had been hypothesised. The source memory models did not include *fact number* as a random effect because source memory difficulty was not expected to differ between statements. For source memory analyses, trials where participants responded "I don't know" to the source memory question were excluded from the analysis (*Experiment 1*: $M = 17.02\%$; *Experiment 2*: $M = 14.0\%$ of trials per participant). Importantly, there was no evidence for social group differences in these responses (*Experiment 1*: $\beta = -0.156$, $SE = 0.15$, $z = -1.01$, $p = .285$; *Experiment 2*: $\beta = -0.124$, $SE = 0.15$, $z = 0.84$, $p = .402$).

Results

For all conducted analyses, tables with fixed effects and confidence intervals can be found in the appendix.

Manipulation Check Analyses

Liking Measures

Liking measures (scale 1-5, averaged over 5 items) for each participant were compared between ingroup (team) and outgroup (opponents) to check if the manipulation of groups was successful. Paired t-tests confirmed that ingroup liking significantly exceeded outgroup liking both before and after the memory task in both experiments. In Experiment 1, ingroup liking was higher than outgroup liking before (*M*s = 5.68 vs. 2.86; $t(50) = 16.20$, $d = 2.27$, $p < .001$) and after the task (*M*s = 5.27 vs. 3.40; $t(50) = 9.58$, $d = 1.34$, $p < .001$). Ingroup liking decreased slightly from before to after ($t(50) = 3.81$, $d = 0.53$, $p < .001$), while outgroup liking increased slightly ($t(50) = -4.13$, $d = 0.58$, $p < .001$). The same pattern held in Experiment 2: ingroup liking was higher than outgroup liking before (*M*s = 5.68 vs. 2.87; $t(43) = 12.94$, $d = 1.95$, $p < .001$) and after the task (*M*s = 5.00 vs. 3.30; $t(43) = 7.35$, $d = 1.11$, $p < .001$), with ingroup liking again decreasing ($t(43) = 7.06$, $d = 1.06$, $p < .001$) and outgroup liking increasing ($t(43) = -2.95$, $d = 0.45$, $p = .005$). The manipulation was considered successful in both experiments, as ingroups were consistently preferred over outgroups.

Novelty of Statements at Encoding

To check the appropriateness of the chosen encoding material, perceived novelty of the statements was observed. Participants rated their perceived novelty for each individual statement (AB or BC) during encoding. Mean novelty averaged over all items was 1.94 (SD = 1.16) in Experiment 1 and 1.88 (SD = 1.14) in Experiment 2, facts were thus overall perceived as novel on the scale 1 (novel) to 5 (known) which indicates an appropriate choice of statements as new learning material. Paired t-tests showed that AB encoding trials were rated significantly more novel than BC encoding trials (*Experiment 1*: $t(1726) = 4.63$, $d = 0.11$, 95% CI [0.06, 0.16], $p < .001$; *Experiment 2*: $t(1514) = 4.33$, $d = 0.11$, 95% CI [0.06, 0.16], $p < .001$), which was deemed acceptable as the AB was always presented first, automatically rendering the B in BC known at the time of presentation.

To investigate whether social group exerts an influence on novelty perception at encoding, a linear mixed model (LMM) was fitted to the data to predict novelty based on the social group. There was no significant social group effect on the perceived novelty of a presented statement in either of the experiments (*experiment 1*: $\beta = 0.03$, $SE = 0.04$, $t(3471.52) = 0.81$, $d = 0.03$, $p = .42$; *experiment 2*: $\beta = -0.01$, $t(3015) = -0.35$, $d = -0.01$, $p = .724$), indicating that at encoding, a statements' novelty was not affected by whether it was presented by an ingroup or outgroup member. Additionally, comparing between the two experimental designs in the pooled dataset found no significant difference between Experiment 1 and Experiment 2 in novelty ratings ($\beta < 0.001$, $SE < 0.001$, $t(9.286e+01) = -0.694$, $d = -0.14$, $p = .489$), a finding that supports comparability of the two experiments.

Main Analyses: Associative Inference Performance

Experiment 1

In Experiment 1, where both encoding statements within an ABC pair were presented by the same persona, the average accuracy of inference trials was 59.6% (SD = 0.17). Split up by the group condition, the average accuracy was 61.5% (SD = 0.19) for ingroup information source and 57.6% (SD = 0.19) for outgroup information source. To test the hypothesis that ingroup presentation of encoding statements would improve associative inference of novel facts, I compared inference accuracy for ingroup and outgroup trials while controlling for block number and individual and item variance in a GLMM. Consistent with the hypothesis, the ingroup condition was associated with significantly higher accuracy than the outgroup condition ($\beta = 0.32$, $SE = 0.12$, $OR = 1.37$, 95% CI [0.081; 0.550], $z = 2.64$, $p = .008$; see Figure 4), indicating that people were better at making novel inferences when the information was presented by an ingroup member than by an outgroup member. Additionally, inference performance improved across blocks (*block 2*: OR = 1.67, $p < .001$; *block 3*: OR = 2.15, $p < .001$).

As a second indicator of inference performance, confidence of answers in correctly answered inference trials was modelled as a function of social group in an LMM. There was no significant social group effect on confidence ratings ($\beta = -0.049$, $SE = 0.03$, 95% CI [-0.120; -0.011], $t(1027.08) = -1.61$, $d = -0.10$, $p = .110$), indicating that the social group of who had presented a piece of information did not influence how confident one was in the inference answer. The main effect of block was significant (*block 2*: $\beta = 0.084$, $SE = 0.04$, $t(1029.56) = 2.17$, $d = 0.14$, $p = .030$; *block 3*: $\beta = 0.099$, $SE = 0.04$, $t(1031.17) = 2.58$, $d = 0.16$, $p = .010$) with confidence increasing over the course of the experiment.

Experiment 2

In Experiment 2, where the encoding statements within a pair were presented by different personas belonging to the same social group, participants had an average inference accuracy of 51.1% ($SD = 0.15$) in all trials (ingroup: $M = 0.533$, $SD = 0.19$; outgroup: $M = 0.497$, SD = 0.17), confirming that participants were able to draw novel inferences across distinct statements, even under these changed presentation conditions.

To test the hypothesis that the ingroup inference advantage would persist under the condition where both integrated statements are linked by social group but not persona, the same GLMM as in Experiment 1 was fitted to the data. In the full sample of Experiment 2, the ingroup presentation was associated with better inference performance, but the effect did not reach statistical significance ($\beta = 0.204$, $SE = 0.12$, $OR = 1.23$, 95% CI [-0.036; 0.444], $z = 1.68$, $p = .093$; see Figure 4) and the main effect of block was significant for block 3 compared to block 1 ($\beta = 0.504$, $SE = 0.15$, $OR = 1.66$, 95% CI [-0.211; 0.801], $z = 1.68$, $p < .001$).

Confidence of correct responses was also analysed for Experiment 2. There was no social group effect on confidence ratings either ($\beta = -0.010$, $SE = 0.04$, 95% CI [-0.087; 0.066], $t(749.23) = -0.267$, $d = -0.02$, $p = .789$) and the main effect of block was significant for block 3 but not 2 (*block 2*: $\beta = 0.069$, $SE = 0.05$, $t(741.02) = 1.43$, $d = 0.11$, $p = .154$; *block 3*: $\beta = 0.127$, $SE = 0.05$, $t(746.38) = 2.67$, $d = 0.20$, $p = .008$).

Associative Inference Performance and Source Memory Answers

Because I assumed the failed significance of the social group effect on inference accuracy in Experiment 2 may have been caused by the small sample size and a potentially weak statistical power for a noisy dataset, I exploratively included source memory (ability to recognise the team that had presented the statements) as an additional covariate to the model.

In this model, which controlled for both block and source memory, ingroup presentation was associated with significantly better associative inference accuracy (β = 0.397, *SE* = 0.14, *OR* = 1.49, 95% CI [0.125; 0.670], z = 2.86, p = .004; see Figure 4), while source memory had no effect on inference accuracy (β = 0.061, *SE* = 0.16, *OR* = 1.06, 95% CI [-0.249; 0.371], z = 0.39, p = .698). The ingroup inference advantage was found. Given that adding source memory as a predictor automatically excluded any trials where participants answered “I don’t know” (n = 249, 17% of trials) to the question of which team had presented the statements, I thus suspected that excluding these trials with no source memory (“I don’t know” answers) cleaned up the noisy data in a way that allowed the social group effect on inference accuracy to be found, regardless of the association between source memory and inference. To test this, I refitted the baseline model (without a source memory predictor) on the sample with complete cases only (excluding “I don’t know” answers). The social group effect in this “clean” sample was almost identical in magnitude and significance to the model including source memory as a predictor (β = 0.397, *SE* = 0.13, *OR* = 1.49, 95% CI [0.125; 0.670], z = 2.86, p = .040), which I counted as a strong indicator that the shift was fully attributable to sample composition rather than source memory as a predictor. This was further supported by a χ^2-test revealing no significant correlation between inference and source memory performance ($\chi^2(1, N = 41) = 0.60$, p = .437, φ = 0.024) in the full dataset of Experiment 2. These findings suggest that the ingroup inference advantage persisted under the conditions of Experiment 2, where two separate individuals presented the encoding statements, with the caveat that the present sample needed to be cleaned up for noise by excluding particularly bad performance trials with no source memory answer at all.

For completeness, I fitted the model including team source memory as a predictor to the data of Experiment 1. In this dataset, associative inference accuracy was correlated with both persona and team source memory (persona: φ = 0.120, χ^2 (1, N = 47) = 19.48, p < .001; team: φ = 0.09, χ^2 (1, N = 47) = 10.87, p < .001). The model found a slightly decreased social group effect (β = 0.269, *SE* = 0.135, z = 1.20, *OR*= 1.31, 95% CI [0.005; 0.532], p = .046), while source memory itself was a significant predictor of inference accuracy (β = 0.285, *SE* = 0.169, z = 2.28, *OR* = 1.33, 95% CI [0.054; 0.715], p = .023). This attenuation of the group effect suggests that source memory partially mediated the ingroup advantage: participants who better remembered the social source of the encoding facts also showed higher inference accuracy. This does not diminish the found ingroup inference advantage in Experiment 1 and potential interpretations of the contradicting patterns in Experiment 1 and 2 are described in the discussion.

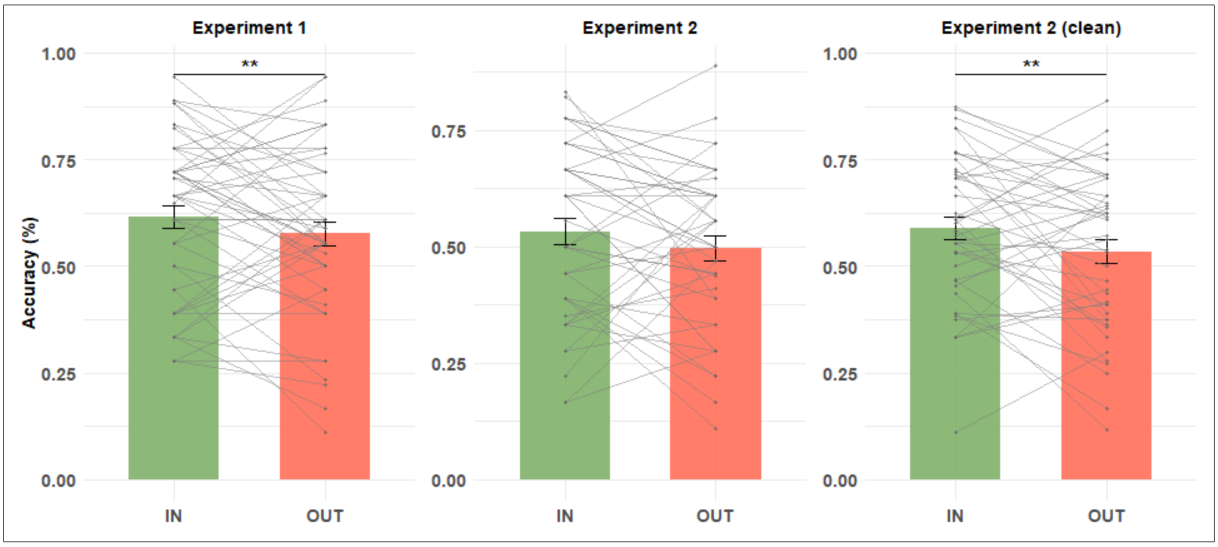
Comparison between Experiment 1 and Experiment 2

To investigate whether the presentation condition (same individual vs. two group members) predicts inference performance or moderates the ingroup inference advantage, the dataset from both experiments was pooled and experimental condition included as a predictor. In the pooled sample, ingroup presentation was associated with significant higher odds of correct inference compared to outgroup presentation ($\beta = 0.299$, $SE = 0.12$, $OR = 1.35$, 95% CI [0.068, 0.529], $z = 2.55$, $p = .011$; see Figure 5), showing that the ingroup inference advantage was observed in the pooled sample across experiments. Participants in Experiment 2 had significant lower inference performance overall compared to Experiment 1 ($\beta = -0.44$, $SE = 0.22$, $OR = 0.64$, 95% CI [-0.865, -0.020], $z = -2.05$, $p = .040$; see Figure 5). This indicates that the ability to draw correct novel inferences declines if the integrated statements are presented by two separate individuals compared to a presentation by the same person. The interaction between social group and experiment (Experiment 1 vs. 2) was not significant ($\beta = -0.093$, $SE = 0.17$, $OR = 0.91$, 95% CI [-0.427; 0.239], $z = -0.55$, $p = .581$), suggesting that there was no difference in magnitude of the ingroup inference advantage between the two experiments.

I also compared the confidence of correct responses between Experiment 1 and 2, there was no significant effect of experiment number ($\beta = -0.076$, $SE = 0.05$, 95% CI [-0.177; 0.024], $t(84.46) = -1.49$, $d = -0.32$, $p = .141$) and no significant effect of social group ($\beta = -0.028$, $SE = 0.024$, 95% CI [-0.075; 0.019], $t(1794.206) = -1.15$, $d = -0.05$, $p = .249$). Confidence ratings on average were the same in the two Experiments.

Figure 4

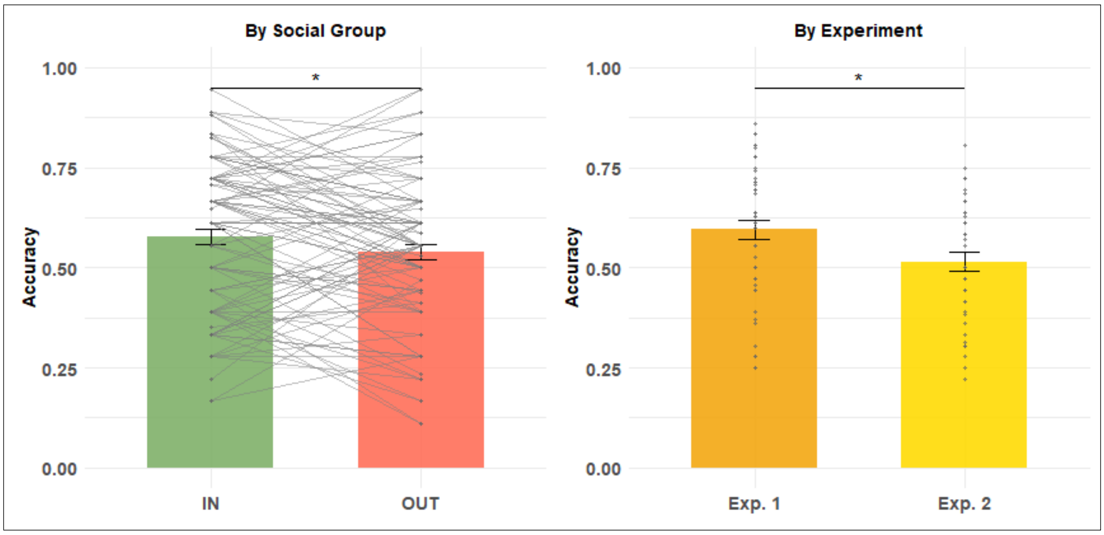
AC Inference Accuracy by Social Group in Experiment 1 and Experiment 2



Note. Mean inference accuracy as a function of source group (ingroup vs. outgroup). Grey lines represent individual participant slopes. Significant ingroup advantage in Experiment 1 (left) and Experiment 2 after excluding "I don't know" source memory responses (right, 'clean'). Significance codes: '**' p < .01.

Figure 5

AC Inference Accuracy in the Combined Dataset (Exp. 1 and 2)



Note. Inference Accuracy as a function of social group (left) and experiment condition (right). Both main effects (expeiriment and social group) were significant (* 'p < .05) but the interaction was not significant. Total $N = 95$.

Novelty as a Moderator of the Ingroup Inference Advantage

As fact novelty can reasonably be expected to impact inference performance, a robustness check was performed in which fact novelty was added to the model predicting inference accuracy. In Experiment 1, familiarity of the statements at encoding (low novelty) was a strong predictor of inference accuracy in a GLMM (β = 0.303, *SE* = 0.090, *OR* = 1.35, 95% CI [0.127; 0.480], z = 3.37, p < .001). The less novel the AB and BC statements were, the better participants performed at inferring the underlying associative link. Yet, novelty did not significantly moderate the group effect on inference: the interaction had a negative estimate but did not reach significance (β = -0.100, *SE* = 0.11, *OR* = 0.91, 95% CI [-0.309; 0.107], z = -0.95, p = .342), failing to support the assumption that under difficult conditions, indicated by novel statements, the ingroup advantage may be more pronounced. Interestingly, the ingroup inference advantage (social group effect) remained significant in the model including novelty as a predictor and moderator (β = 0.510, *SE* = 0.24, *OR* = 1.67, 95% CI [0.040; 0.981], z = 2.12, p = .034).

In Experiment 2, the GLMM with a novelty moderator revealed the same pattern of results: Familiarity was a strong predictor of inference accuracy (β = 0.267, *SE* = 0.094, *OR* = 1.31, 95% CI [0.083; 0.451], z = 2.84, p = .005), the social group effect was not significant (β = 0.236, *SE* = 0.24, *OR* = 1.27, 95% CI [-0.231; 0.703], z = 1.00, p = .322), and novelty did not significantly moderate the strength of the ingroup inference advantage (*interaction*: β = -0.018, *SE* = 0.11, *OR* = 0.98, 95% CI [-0.233; 0.199], z = -0.16, p = .871).

Table 2

Means for Source Memory Accuracy

Source Memory for Persona			
Experiment 1			
Trial	Mean (SD)	CI 95%	Chance
Overall	0.574 (0.15)	[0.530; 0.618]	0.25
Ingroup	0.583 (0.19)	[0.526; 0.640]	0.25
Outgroup	0.564 (0.18)	[0.511; 0.618]	0.25

Source Memory for Team					
	Experiment 1		Experiment 2		
Trial	Mean (SD)	CI 95%	Mean (SD)	CI 95%	Chance
Overall	0.782 (0.12)	[0.747; 0.817]	0.701 (0.14)	[0.657; 0.744]	0.5
Ingroup	0.766 (0.15)	[0.722; 0.810]	0.701 (0.5)	[0.653; 0.748]	0.5
Outgroup	0.801 (0.15)	[0.758; 0.843]	0.706 (0.17)	[0.651; 0.760]	0.5

Note: Experiment 1: N = 47; Experiment 2: N = 41. Dichotomous Scoring of Answers with 0 = False and 1 = True.

Source Memory

In both experiments, participants performed above chance at recognising both the persona (individual) and the team (group) which had earlier presented the encoding statements (see Table 2) I examined this to ensure that participants were not guessing their responses. Source memory was scored dichotomous as correct or wrong, “I don’t know” answers were excluded from the analyses, and the chance levels were 0.5 (1 of 2) for the correct team and 0.25 (1 of 4) for the correct persona.

Experiment 1

A GLMM predicting source memory accuracy based on inference accuracy and social group (in- vs. outgroup) was fitted to the data for persona and team source memory respectively. Consistent with my hypothesis, source memory was better for correctly inferred AC associations than for incorrect inference trials, this was observed both for team memory ($\beta = 0.559$, $SE = 0.20$, $OR = 1.75$, 95% CI [0.166; 0.951], $z = 2.79$, $p = .0049$) and persona memory ($\beta = 0.707$, $SE = 0.17$, $OR = 2.03$, 95% CI [0.374; 1.040], $z = 4.16$, $p < .001$), suggesting that when participants were able to draw the AC inference, they were also more likely to remember the team and persona that had previously presented the statements.

Team source memory (whether the team was correctly remembered) did not significantly differ between ingroup and outgroup ($\beta = 0.040$, $SE = 0.21$, $OR = 1.04$, 95% CI [-0.373; 0.453], $z = 0.19$, $p = .849$) and the interaction between group and inference accuracy did not reach significance either ($\beta = -0.340$, SE = 0.28, $OR = 0.71$, 95% CI [-0.881; 0.202], $z = -1.23$, $p = .220$; see Figure 6). These results suggest that both teams were remembered equally well, contrary to the hypothesis that in incorrect inference trials, the outgroup would be remembered better.

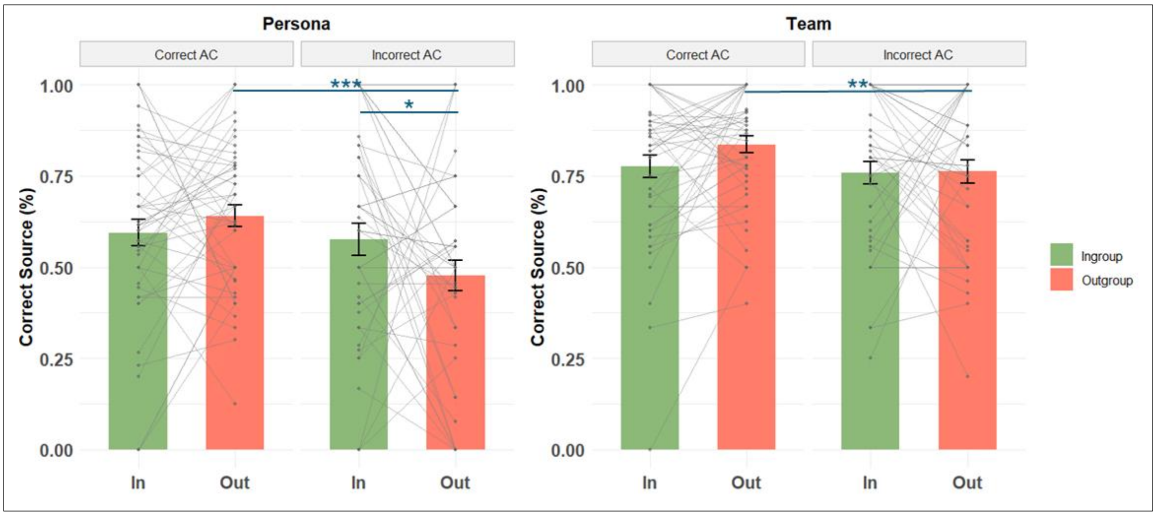
However, persona source memory, that is the ability to remember the persona who had presented the facts, was significantly better for ingroup compared to outgroup ($\beta = 0.398$, $SE = 0.19$, $OR = 1.49$, 95% CI [0.029; 0.767], $z = 2.11$, $p = .035$) and the interaction between inference accuracy and social group was also significant ($\beta = 0.521$, $SE = 0.24$, $OR = 1.68$, 95% CI [-0.987; -0.054], $z = -2.19$, $p = .029$; see Figure 6). Post-hoc analyses on subsets revealed that when AC was correct, there was no difference between ingroup and outgroup source ($\beta = -0.104$, $SE = 0.15$, $OR = 0.90$, 95% CI [-0.632; 0.071], $z = -0.71$, p = .476), while for incorrect AC trials, source memory was significantly better for the ingroup than the outgroup ($\beta = 0.386$, $SE = 0.19$, $OR = 1.47$, 95% CI [0.020; 0.751], $z = 2.07$, $p = .039$). Consequently, outgroup persona memory was significantly better in correct than incorrect AC trials (β = 0.717, *SE* = 0.18, *OR* = 2.05, 95% CI [0.362; 1.072], *z* = 3.96, *p* < .001) and this effect also gained significance for team memory (β = 0.577, *SE* = 0.21, *OR* = 1.78, 95% CI [0.176; 0.977], *z* = 2.82, *p* = .0048), while there was no significant difference on ingroup persona memory (*team*: β = 0.281, *SE* = 0.20, *OR* = 1.32, 95% CI [-0.102; 0.664], *z* = 1.44, *p* = .150; *persona*: β = 0.211, *SE* = 0.18, *OR* = 1.23, 95% CI [-0.151; 0.573], *z* = 1.14, *p* = .253). The overall difference between correct and incorrect trials in source memory thus appeared to be driven by the difference in outgroup source memory (see Figure 6).

Experiment 2

In Experiment 2, where both encoding statements within a pair were presented by different members of the same team, source memory was only measured for the team, recording per trial whether participants were able to identify the team that had presented the statements. Calculating the same analyses as in Experiment 1, yielded no significant results in Experiment 2. Neither the social group of the source (β = -0.087, *SE* = 0.20, *OR* = 0.92, 95% CI [-0.471; 0.298], *z* = -0.44, *p* = .658), nor the correctness of the AC inference had a significant effect on source memory (β = -0.021, *SE* = 0.19, *OR* = 0.98, 95% CI [-0.389; 0.347], *z* = -0.11, *p* = .911). Lastly, the interaction between group and inference accuracy also did not reach significance (β = 0.060, *SE* = 0.26, OR = 1.06, 95% CI [-0.455; 0.575], *z* = 0.23, *p* = .819) (see Figure 8). These results showed no support for our hypothesis but also revealed no indication of an interaction in the opposite direction, as was the case in Experiment 1. How well the inference was drawn and how well the source was remembered appeared to be unrelated in the dataset of Experiment 2.

Figure 6

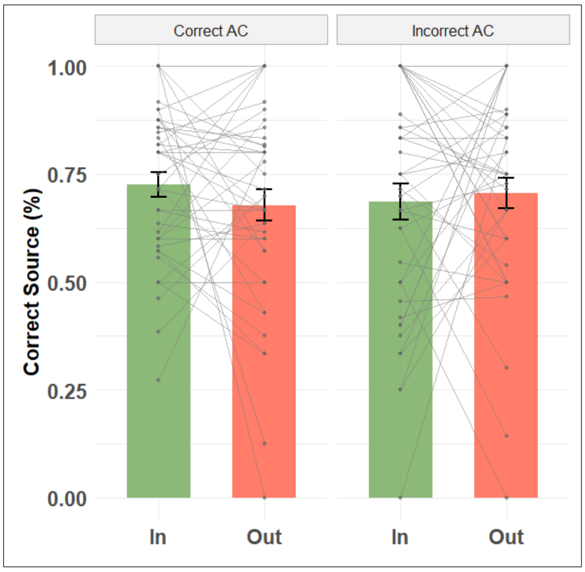
Source Memory Performance Interactions in Experiment 1



Note. Source memory accuracy as a function of social group on either a persona level (left) or a team level (right). Split up by correctness of inference trials. Significance: * = '$p < .05$' for the difference between ingroup and outgroup on incorrect trials for persona source memory. ** = '$p < .01$' for the difference between correct and incorrect outgroup trials for team source memory. *** = '$p < .001$' for the difference between correct and incorrect outgroup trials for persona source memory. Grey lines are individual slopes for participants.

Figure 7

Source Memory Performance (Team) in Experiment 2



Note. Team source memory, the accuracy of recognising the team that had presented the statements at encoding. The figure shows averages and individual slopes (grey lines) split up by inference correctness and social group.

Discussion

The purpose of this study was to investigate how the social group identity of an information source influences our ability to integrate that new information into memory. Experiment 1 tested this in a naturalistic setup with real-world semantic content and a cued recall task. Experiment 2 then explored the limits of this effect, specifically whether the memory integration advantage for ingroup-sourced information required the integrated information to share one source individual, or whether the effect also appeared when the information came from separate individuals within one social group. Additionally, the experiments tested if the group effect on memory integration was caused by a trade-off between source memory and item memory due to limited resources during encoding, by measuring how well the person and team presenting the encoding items were remembered.

While both experiments generally found an ingroup inference advantage, the effect was stronger when one persona presented both facts compared with two personas from the same group presenting the facts. Additionally, I did not find a trade-off between inference performance and source memory.

The associative inference paradigm with factual knowledge stimuli.

First of all, it is important to note that the stimuli and the paradigm used were adequate. Inference accuracy averaged at 50-60%, comparing well to prior work with factual knowledge stimuli (Varga & Bauer, 2017), and source memory performance was above chance in both experiments. Both indicated that the task was adequate in difficulty and that participants were able to form novel associations across overlapping encoding events. The high perceived novelty of the statements further confirmed that the stimuli were appropriate new learning materials. Inference accuracy and confidence both improved across blocks, reflecting an acceptable learning effect in the absence of a practice block, which the applied models can control for without undermining the validity of the results. Together, the findings provide support that the observed effects reflect real memory processes rather than floor or ceiling artifacts, and that the paradigm is well-suited for investigating group-based influences on associative inference in future research.

Ingroup sources facilitate the inference of novel information across overlapping but distinct events.

The applied group manipulation was successful. The liking measures showed that the ingroup was consistently liked better than the outgroup both before and after the experiment across interpersonal dimensions, such as trust and interaction preference, which have been associated with group-based memory effects (Hope et al., 2008).

I consistently observed an ingroup inference advantage. That is, participants were more likely to make correct novel inferences if the information was presented by ingroup compared to outgroup sources. In Experiment 1 and in the combined dataset, this group effect was clear. In Experiment 2, the ingroup advantage was observed when controlling for source memory. These findings support the main hypothesis and corroborate the findings by Boeltzig et al. (2023): receiving information from a person or group that is considered trusted, liked, or similar to oneself (e.g., Brewer, 1999; Chae et al., 2022), facilitates the integration of novel information into the knowledge base.

The demonstration of an ingroup inference advantage with factual knowledge stimuli is particularly noteworthy. Unlike abstract or arbitrary stimuli such as random objects (Boeltzig et al., 2023) or word-colour pairs (Jeon et al., 2021), factual statements about the world are embedded in rich networks of prior knowledge and have subjective relevance

(Raykov et al., 2022). Participants may find some facts more plausible than others, may hold pre-existing opinions or attitudes about the content, or may differ in how much they already know about the topic. Any of these factors could interact with or even suppress a memory effect. That the ingroup inference advantage emerges robustly despite the stimuli being noisy and complex, speaks to the strength and generalisability of the effect.

Equally interesting is that the effect was found in a non-American sample without political priming. The previous demonstration of the effect relied on salient and emotionally charged group identities (Boeltzig et al., 2023) which can limit generalisability. Here, participants self-created their own groups and attributes in a low-stakes context and yet the ingroup advantage was found in both experimental designs of the present study. This suggests that the effect is not just produced by artificial political priming or a particular culture or group identity but instead a robust feature of how social context shapes memory integration. The findings indicate that social group effects on associative inference may even match the well-established ingroup advantages in general memory abilities (e.g., Enock et al., 2018; Jeon et al., 2021) in their robustness.

Confidence in inference answers predicts accuracy but is not affected by social groups.

However, this effect did not extend to confidence, the second measure of inference performance. Neither experiment found an association between ingroup presentation and higher confidence in inference responses. Though the ingroup was consistently perceived as more trustworthy and credible, that did not translate into subjective certainty about one's answers. Several explanations are possible. Methodologically, the three-point confidence scale may have lacked sensitivity to detect subtle group differences, and a more fine-grained scale could be appropriate for future research. The cued-recall format may have also played a role. In 2AFC tasks, as was used by Boeltzig et al. (2023), the lure has been suggested to influence the confidence in the given answer based on the magnitude of difference in evidence between target and lure (Horry & Brewer, 2016; Zawadzka et al., 2017). Both the absence of a lure and the open response format likely changed the confidence variance in ways that could obscure social group effects.

This null effect is surprising given that I found a strong relationship between confidence and accuracy. One possibility is that ingroup sources influence memory processes implicitly during encoding or retrieval, without generating a conscious sense of greater certainty. Participants may have benefited from ingroup sources in terms of actual memory performance, but without consciously attributing that benefit to the source's group identity, and therefore without expressing greater confidence. This would suggest a dissociation between the objective and subjective effects of group trustworthiness on memory performance. Whether this reflects a cognitive mechanism or an artefact of the present design remains an open question.

The ingroup inference advantage persists when integration requires binding across two individuals from the same social group but may rely on successful source encoding.

Experiment 2 altered the original paradigm by a theoretically critical manipulation: rather than having both encoding statements of an ABC triplet presented by the same persona, each statement was presented by a different individual, both from the same social group. This was done to test whether the ingroup inference advantage required a consistent individual or whether group membership itself could produce the effect. The comparison between the two experimental conditions was then used as an initial test of whether group members function as cognitively interchangeable sources in the integration process. Equivalent performance in the two experiments would suggest group-level encoding, while weaker performance in Experiment 2 could point to a stronger role of individual-level encoding (e.g., Crawford et al., 2002).

Experiment 2 successfully found the ingroup inference advantage in its more demanding design, which demonstrates that the effect likely does not require a single consistent individual to present both integrated facts. Instead, group membership alone may be sufficient to produce the benefit for inference performance. This is meaningful, because it suggests that when information is encoded, it is not only linked to the specific individual who presented it but also to their social group, resulting in the group members becoming interchangeable as sources to some extent. The mechanism seems to be located on a group-level: it is the group identity of the source, rather than the specific person, that facilitates the integration of overlapping information into novel references.

At the same time, overall inference accuracy was stronger in Experiment 1 than 2, while the magnitude of the ingroup inference advantage showed no meaningful difference between the two experimental conditions. The general decrease in inference performance was anticipated and is most plausibly due to task difficulty: in Experiment 2, participants had more information to encode and could not link the two facts within a pair via a shared persona. This likely made integration harder and increased cognitive load. The null result for the moderation of experiment on social group effects leaves the question whether in a more powerful sample and cleaner conditions, a meaningful difference between person- and group-level binding of information could be uncovered or whether the magnitude of the effect is unrelated to the conditions and task difficulty.

In Experiment 2 the ingroup inference effect only reached significance after excluding trials on which participants reported no source memory at all (“I don’t know” responses). One possible explanation for this is that the data in the smaller sample of Experiment 2 with more difficult encoding conditions was simply noisier than the data in Experiment 1. Cleaning it up by excluding trials where participants were potentially inattentive or unengaged, may have cleaned the data enough to make the ingroup advantage visible. Another theoretically relevant explanation could be that the ingroup advantage relies on successful encoding of the source (the person who presented the fact) on the group level. When participants retained no memory of the social group that had presented the information, the social group signal, and with it the inference benefit, appears to have been lost. This is supported by the findings here, where trials with no source memory hindered the ingroup advantage, but it was also supported in Experiment 1, where successful source memory was strongly associated with inference performance. More on this in the next section.

Taken together, the findings from Experiment 2 support and refine our understanding of the ingroup inference advantage. Group membership itself seems to be sufficient to drive the effect, but person-level binding appears to produce stronger and more reliable integration, possibly by providing a more salient associative link between overlapping encoding events. The dependence of the effect on source encoding in Experiment 2 warrants further investigation, particularly with larger samples and designs that can more cleanly disentangle task difficulty from binding level.

Memory for the information source varies with inference accuracy and shows an ingroup advantage in incorrect trials.

Two hypotheses were tested regarding source memory. First, that source memory would be positively associated with inference accuracy, which was confirmed in Experiment 1. Second, that outgroup source memory would be better than ingroup source memory, reflecting a trade-off in attentional resources, which was not only rejected but even somewhat contradicted by the data.

In Experiment 1, source memory was significantly better in correctly answered inference trials than in incorrect ones, supporting the first hypothesis and suggesting that source and item memory are linked. This is theoretically plausible: For episodic memory in general, source memories help to provide enriched context and are beneficial to retrieval when they can be used as cues (e.g., McDermott & Roediger III, 2025; Spens & Burgess, 2024). Here, while the faces cannot be used as context cues during retrieval (because they are not shown on the screen), the face of the presenting individual is encoded simultaneously with the fact and likely gets bound to it in the memory trace (Yonelinas et al., 2019), providing an additional overlapping element between the two statements that facilitates inference, whether through integrative encoding (Schlichting & Preston, 2015; Zeithamova & Preston, 2017) or flexible retrieval (Carpenter & Schacter, 2018a, 2018b). This interpretation is further supported by the finding that source memory likely partially mediated the ingroup inference advantage in Experiment 1, suggesting that the social group effect on inference operates at least in part through more successful source binding. The findings indicate that during the task, participants did not just integrate the pair of statements during encoding and then discarded the faces, instead the faces were part of the encoded representations and were remembered better, if memory for the items was retrievable.

The second hypothesis, however, found no support. Rather than an outgroup advantage in source memory, I found the opposite pattern: ingroup persona memory was significantly better than outgroup persona memory, specifically in incorrectly answered trials. This directly contradicts the trade-off account proposed by Boeltzig et al. (2023) which predicts that under difficult encoding conditions, attentional resources are redirected toward monitoring less trustworthy outgroup sources, producing better outgroup source memory at the cost of inference performance (Carpenter & Schacter, 2018a, 2018b; Lindsay & Johnson, 2000). I found no evidence for this mechanism. Instead, the found pattern is better explained by the well-established general memory advantage for ingroup-associated stimuli (e.g., Enock et al., 2018; Jeon et al., 2021): even under challenging encoding conditions that impair inference, ingroup faces may still be encoded relatively well due to their generally lower processing demands (e.g., Enock et al., 2018; Herzmann & Curran, 2013; Tüttenberg & Wiese, 2023), while outgroup faces suffer more under the same conditions. In correctly answered trials, encoding resources were seemingly sufficient for source memory regardless of group. Here, no group difference was found.

One possible reason for why the present results diverge from Boeltzig et al. (2023) is that the nature of the stimuli matters: factual statements embedded in rich prior knowledge networks may allow deeper, more elaborative encoding and leave less room for credibility-based source monitoring to play a relevant role. When participants can engage with the content itself (for example evaluate its plausibility or connect it to existing knowledge), the trustworthiness of the presenting persona may become less influential than in designs using arbitrary object-associations that don't allow these deeper processing steps and where then credibility of the source weighs more heavily.

Beyond the type of stimuli, the overall encoding demands also differed substantially between the two designs. In Boeltzig et al. (2023), participants were required to simultaneously encode an object, a face, and a background scene. This can be regarded as a considerably more crowded and demanding encoding situation than the present study, in which only a statement and a face were presented together. This increased complexity may have heightened overall encoding difficulty, making it more likely that attentional resources were differentially recruited based on source trustworthiness. The relative ease of encoding in the present study, further supported by the use of semantically rich sentences that can be integrated into existing knowledge structures, may thus have removed the conditions under which credibility-based source monitoring becomes consequential.

A related and broader question is whether the faces in the present design were even encoded as information sources in the first place, or whether they functioned more as part of the item memory itself. Participants were explicitly instructed to remember both the faces and the statements, which may have led them to encode the face-statements pairings as integrated units rather than as source-item relationships in the traditional sense. If the face was not treated as the conveyor of information but simply as another feature of the encoded event, trust and credibility toward the social group may have had little opportunity to influence source monitoring. This could also explain why I find no evidence for the proposed trade-off mechanism. This interpretation is consistent with the finding that any ingroup advantage in source memory can be accounted for by the general memory advantage for ingroup-associated stimuli, regardless of whether the face is treated as a source or an item.

It is worth noting, however, that this account does not fully resolve the discrepancy with Boeltzig et al., (2023). Research by Jeon et al. (2021) demonstrated that even a simple colour cue presented before a word, without any source framing at all, is sufficient to shape encoding based on group membership. This suggests that the presence of an ingroup or outgroup face during encoding may influence memory independently of whether it is explicitly processed as a source, which does not fully fit to the pure item-encoding explanation and suggests the mechanisms at play here may be more complex than either account alone can explain.

Experiment 2 yielded no significant source memory findings, which I attribute primarily to the noisier encoding conditions and smaller sample size rather than a theoretically meaningful null result, particularly given that persona-level effects were already subtle in Experiment 1.

Familiarity of items predicts inference performance but does not moderate the group effect.

Another variable of interest was the perceived novelty of the facts at encoding. In both experiments, item familiarity emerged as a reliable predictor of associative inference: the more familiar a pair of items was at encoding, the more likely participants were to correctly draw the inference between them. This aligns with established findings that prior knowledge and existing schemata facilitate the encoding and integration of new information (e.g., Sridhar et al., 2023) and can in part be attributed to the use of naturalistic factual statements, which meant some participants already knew a subset of items prior to the experiment. While prior knowledge of some stimuli complicates the assessment of knowledge acquisition, the task reflects the theoretically meaningful point that semantic knowledge is collected over a lifetime and constantly updated (Sridhar et al., 2023; Varga & Bauer, 2017), meaning that inference draws on prior knowledge and recently integrated information alike.

Novelty did not, however, significantly moderate the ingroup inference advantage, though there was a non-significant tendency toward a smaller ingroup advantage for more familiar items. If novelty is considered as an encoding demand, this direction is consistent with what the source monitoring resources hypothesis would predict (Boeltzig et al., 2023): stronger social group difference on inference under difficult conditions. Yet, the overall pattern of results discussed above already offers little support for that account, making the absence of a significant moderation unsurprising.

It should be noted that familiarity ratings are only an indirect proxy for encoding difficulty. Future research with experimentally manipulated difficulty and sufficient statistical power would be better suited to test whether encoding demands modulate group effects on associative inference.

Limitations of the Present Study

The most significant limitation of the present study is the small sample size. Neither experiment reached the $N = 68$ that Boeltzig et al. (2023) calculated as necessary for sufficient statistical power (80%) for this paradigm. This may well be the reason that the ingroup inference advantage did not reach significance in the full sample of Experiment 2 with more difficult conditions. Small samples also limit generalisability and future replications and more diverse samples are needed before a definitive conclusion can be drawn about the boundaries of the social group effect on inference.

A second limitation concerns the online setting. This can partly be reframed as a strength: the effects emerge even under conditions of reduced control and engagement and true effects may be even stronger in in-person experiments. Nevertheless, online participation introduced uncertainty about how carefully participants read instructions, how distracted they were, and how consistently they engaged with the task, all of which can influence data quality. More broadly, the computer-based presentation of the stimuli differs a lot from real-life social interaction. While the design is valuable because it is easy to conduct, provides controlled conditions and is a step towards more naturalistic cognitive research, the operationalisation only included reading facts loosely associated with photographs of people. This differs from real-life and even virtual interactions with an avatar, because the participant did not respond or truly interact with the personas. This should be kept in mind when interpreting the findings.

Several measurement limitations also deserve mention. Perceived entitativity and source credibility were both discussed as potentially theoretically relevant factors but neither was explicitly measured, which limits the conclusions that can be drawn about the mechanisms underlying the effects. Credibility in particular would ideally be assessed at the trial level, which I did not do to keep the already lengthy experiment manageable and to maintain comparability with Boeltzig et al. (2023). For the same reason, confidence was only measured with a brief three-item scale, which may have lacked the nuance to detect more subtle effects.

Finally, two conceptual caveats should be noted. The present experiments measured inference performance shortly after encoding, within the same experimental session, which means the claim that associative inference reflects genuine knowledge extension should be treated cautiously. Longer retention intervals, as used by Bauer et al. (2020) and Varga & Bauer (2017), are needed to support stronger claims about integration into long-term knowledge. Additionally, it would be reasonable to question the boundary between episodic and semantic memory in the present design. I frame the paradigm as episodic memory integration because I am interested in how two encoded events are linked and later used to draw novel inferences, and because participants retain contextual memory for the encoding episodes, as evidenced by source memory performance. Nevertheless, the design shares features with semantic memory research.

Future Research Directions

The present findings present several options for future research directions. Most immediately, a well-powered replication study should aim to confirm the tentative findings from Experiment 2 that the ingroup inference advantage persists when integration occurs across two different members of the same social group. Beyond replication, a systematic manipulation of the group identity itself would help to clarify the boundary conditions of the effect. Minimal group paradigms (Tajfel, 1970, 1974), where group membership is based on seemingly arbitrary criteria such as colour preference, could test whether the effect requires meaningful identification with the ingroup or whether it emerges even when group membership is affectively weak. The present study used self-chosen attributes including hobbies and political orientation, which likely produced moderate to strong group identification. It remains to be investigated how far the effect extends toward more minimal or emotionally neutral group compositions.

Future research could also investigate the temporal dynamics of the ingroup inference advantage. The present study did not aim to investigate at which point in the integration process social group information has its influence. There is an ongoing debate on whether memory integration occurs during encoding of the second event (see e.g., Schlichting & Preston, 2015; Zeithamova & Preston, 2017) or is flexibly reconstructed at retrieval (see e.g., Carpenter & Schacter, 2018a, 2018b). Recent findings suggest that segregation and integration processes during encoding may run in parallel (e.g., Liu et al., 2026; Molitor et al., 2021), but findings are not conclusive yet and there is no study exploring temporal dynamics in interplay with social group factors. EEG methods could shed light on whether ingroup information is already processed more actively during encoding or whether group membership modulates engagement during retrieval. Similarly, fMRI studies could investigate whether the ingroup inference advantage is reflected in neural synchronisation patterns, building on findings that neural oscillations in the default mode network synchronise more strongly the closer one feels to a conversation partner (Menon, 2023).

The role of source memory also warrants further investigation. The present findings suggest that accurate source memory is beneficial to inference and contributes to the ingroup advantage, but as discussed, the design leaves open whether the faces were encoded as true information sources or simply as additional features of the item memory. Future research should explicitly manipulate this distinction. This could for example be operationalised through more naturalistic paradigms using videos of people saying the encoding statements, where the speaker more clearly functions as the source of information rather than a potential part of the item memory. This would also allow a cleaner test of whether credibility- and trust-based source monitoring plays a role, which the present study design was not able to conclusively establish.

A potential additional analysis of the present data that I did not have the time to complete, concerns the errors that participants made during the inference task. Errors could be categorised into “no answer”, “incomplete answers”, “intrusions from the same or a different pair of statements”, and “new words”. Particularly the case where participants answered with a word that came from a different set of encoding statements, so for example: ‘*Apple seeds contain ..oil’*, after another AB statement had been ‘*Shark livers contain oil’*, are interesting to analyse. Investigating whether intrusions are more likely to stem from statements presented by the ingroup, could indicate at a new type of ingroup advantage. Similar to De Sousa Mestre & Rygert's (2024) findings that false information was accepted more easily when it was presented by the ingroup.

Lastly, the generalisability of the ingroup advantage effect is still limited by using a young, highly educated, predominantly female student sample. Future studies should test the effects on samples broader in age and educational background. Older adults for example have been found to have deficits in associative memory and inference abilities compared to younger adults (Charles & Bowman, 2025), while at the same time they are described as more rigid in their group stereotypes (Schwaba et al., 2018) and psychological flexibility (Plys et al., 2023). Associative inference as a process of knowledge acquisition has been tested in school children by Bauer et al. (2020), but so far without the addition of social group influences. Age-comparative designs are a valuable next step with implications for how group biases in memory develop across the lifespan.

Implications of the Findings

Cognitive functions such as memory are frequently studied under tightly controlled laboratory conditions that deliberately minimise social influences, either to control for confounding variables or because simpler paradigms are more feasible. However, the present results show that even the most minimal and artificial social manipulations, like self-chosen group attributes and photographs on a screen, are sufficient to produce meaningful effects on basic cognitive functions. If social context has this kind of influence under such stripped-back conditions, its role in naturalistic everyday cognition is likely far greater. This should inspire to take social factors seriously even in research on ostensibly basic processes.

The implications of these findings reach beyond the laboratory. Growing evidence for the existence of an ingroup inference advantage can be connected to a natural tendency to construct a shared reality with ingroup members, where people preferentially seek and retain information that aligns with their social group's worldview (e.g., Jost et al., 2022). This tendency is already well-established as a mechanism contributing to filter bubbles and political polarisation, particularly in the context of social media environments that algorithmically reinforce group-consistent information exposure and encourage users to stay in echo chambers aligning with their ingroup perspectives (Flaxman et al., 2016). The present findings suggest that memory integration may be an additional and understudied pathway through which this polarisation is deepened. If information received from ingroup sources is not only more readily accepted (e.g., Bramão, 2025) but also more efficiently integrated and used as a basis for novel inferences, then societal consequences could arise. Knowledge with ingroup sources may be more easily integrated and potentially more deeply embedded in one's semantic memory network. In turn, it may then also be more easily retrieved and becomes more likely to inform future decisions and opinions, which could affect even topics and contexts far away from the original source. This ingroup favouring creates an asymmetry in how knowledge is collected across social groups: shared ingroup narratives build a structural memory advantage over outgroup-sourced information, not necessarily because they are more accurate or more carefully evaluated, but simply because of who conveyed them. Existing evidence shows that people are also more likely to accept false information (e.g., Pennycook & Rand, 2021) and false inferences (Bramão, 2025) from ingroup sources. Combined, this could mean that false information that is spread through trusted ingroup channels is believed more readily and integrated more robustly into memory to then generate further inferences about beliefs and attitudes.

At a more applied level, the findings carry relevance for anyone working with how information is received and integrated. Teachers or public health communicators for example, may use group dynamics deliberately, by communicating information with an awareness of the audiences ingroup or outgroup and fostering a sense of shared identity. Policy makers and platform designers on the other hand should be mindful of source group influences in their effort to prevent the spreading of misinformation and hate-speech.

Conclusion

The present study shows that ingroup inference advantage under naturalistic conditions and without partisanship priming. Drawing novel inferences between learned overlapping but distinct facts is influenced by the social group of the person presenting the information in a way that inferences are easier when the information is presented by ingroup sources. The study further provides first promising evidence that group membership itself, rather than a consistent individual identity may be sufficient to drive this effect. Though the mechanisms underlying the ingroup effect warrant further investigation with larger samples and I found no support for a resource allocation trade-off between source monitoring and inference effort based on trust towards the group, the findings support a facilitation of ingroup source monitoring under difficult conditions.

Overall, the findings serve as a reminder that knowledge acquisition is not a purely cognitive process. Who tells us something shapes how well we encode it, how readily we integrate it with existing knowledge, and how likely we are to draw on it when forming future opinions and inferences. In a polarised world where ingroup and outgroup distinctions are increasingly consequential, this asymmetry in how information from different sources is processed and retained deserves attention. Cognition even at its base does not happen in a vacuum, it happens between people.

Declaration on the Use of Generative AI

In this thesis, generative AI (Claude, *Sonnet 4.6*) was employed to assist in writing R scripts for data preprocessing and the generation of plots. During this, no participant data or confidential materials were uploaded to or processed by any AI system.

AI was also used to help understand complex theoretical concepts, but no AI was used to write, draft, or structure any part of the text. The final analysis, interpretations, and conclusions remain entirely the responsibility of the author.

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Appendix

Method

Group Attributes

Participants chose one attribute per category to assign to team members and opponents. This was part of the group manipulation and intended to make the groups appear more similar/different and likeable/not likeable to the participant, which would increase the ingroup vs. outgroup distinction necessary for group effects. The chosen attributes could not be the same for both groups.

Politics	Major	Eating	Music	Sports	Hobby
Far-Left, Far-Right, Political Centre, Leaning Left, Leaning Right	Business, Languages, Psychology, Law, Natural Sciences	Meat in every meal, Meat occasionally, Vegetarian, Mostly Vegan, Strictly Vegan	Pop, Hip-Hop, Classical, Folk Music, Rap	Tennis, Golf, Yoga, Soccer, Fitness	Hunting and Fishing, Cooking and Baking, Playing instruments, Social Activities, Video Gaming

Liking Measure Items

After creating the two teams and imagining real-life encounters with the team members, participants answered these five questions on a 7-point Likert scale for team and opponents respectively. The questions are based on the questionnaire by Veksler & Eden (2017) and have been previously used by (Boeltzig et al., 2023).

1. I would like to get to know these people better.
2. I think that these people and I may have a lot in common.
3. I think that these people exhibit good judgement.
4. There are aspects of these people’s personalities that I admire.
5. I think that future interactions with these people would be pleasurable.

Scoring Rules for AC Inference Responses

Responses with spelling mistakes, if the word was still recognisable, counted as correct. Responses with only half the required C (e.g., “foam” instead of “sea foam”) counted as wrong. Close synonyms (e.g., “ocean” instead of “sea”) counted as correct. Distant synonyms (e.g., “rain” instead of “moist air”) counted as wrong. Scoring strictly followed a list for these synonym rules to ensure identical scoring for all participants in both experiments.

Results

Novelty of Statements at Encoding

LMM predicting Novelty based on Social Group (Experiment 1)

Predictor	**β**	**SE**	**t**	**p**	**95% CI**	**Sig.**
Intercept	1.971	0.137	14.43	< .001	[1.703; 2.239]	***
Group (in vs. out)	0.031	0.038	0.81	.417	[−0.044; 0.106]	
Block 2 (vs. 1)	−0.020	0.047	−0.41	.680	[−0.113; 0.073]	
Block 3 (vs. 1)	−0.115	0.047	−2.44	.015	[−0.208; −0.023]	*

Note. LMM: *novelty ~ social group + block + (1|participant) + (1|stimulus fact)*.
Significance codes: '***' p < .001; '**' p < .01; '*' p < .05

LMM predicting Novelty based on Social Group (Experiment 2)

Predictor	β	SE	t	p	95% CI	Sig.
Intercept	1.902	0.138	13.76	< .001	[1.631; 2.173]	***
Group (in vs. out)	−0.014	0.040	−0.35	.724	[−0.093; 0.064]	
Block 2 (vs. 1)	−0.006	0.049	−0.11	.911	[−0.102; 0.091]	
Block 3 (vs. 1)	−0.027	0.049	−0.55	.582	[−0.124; 0.069]	

Note. LMM: *novelty ~ social group + block + (1|participant) + (1|stimulus fact)*.
Significance codes: '***' p < .001; '**' p < .01; '*' p < .05

Associative Inference Performance

Associative Inference Performance Means

	Experiment 1		**Experiment 2**		**Combined**	
Source	Mean (SD)	CI 95%	Mean (SD)	CI 95%	Mean (SD)	CI 95%
Overall	0.596 (0.17)	[0.548;0.643]	0.515 (0.15)	[0.469;0.562]	0.558 (0.17)	[0.525;0.592]
In	0.615 (0.19)	[0.562;0.668]	0.533 (0.19)	[0.476;0.590]	0.577 (0.19)	[0.538;0.616]
Out	0.576 (0.19)	[0.522;0.631]	0.497 (0.17)	[0.445;0.550]	0.540 (0.19)	[0.502;0.578]

Note: Experiment 1 (1836 Trials, N = 51), Experiment 2 (1584 Trials, N = 44), Combined (3420 Trials, N = 95).

Confidence Ratings for Inference Answers Means (and SD)

	Experiment 1		**Experiment 2**	
	Correct Trials	All Trials	Correct Trials	All Trials
Overall	2.70 (0.54)	2.31 (0.82)	2.65 (0.61)	2.19 (0.85)
Ingroup	2.67 (0.58)	2.32 (0.82)	2.65 (0.62)	2.18 (0.86)
Outgroup	2.74 (0.48)	2.31 (0.82)	2.65 (0.60)	2.21 (0.84)

Note. Experiment 1 N = 51, Experiment 2 N = 44.

Fixed Effects of Models:

GLMM predicting Inference Accuracy based on Social Group (Experiment 1)

Predictor	β log odds	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	0.001	0.318	0.005	.996	1.00	[-0.622; 0.625]	
Group (in vs. out)	0.315	0.120	2.64	.008	1.37	[0.081; 0.550]	**
Block 2 (vs. 1)	0.514	0.146	3.51	<.001	1.67	[0.227; 0.801]	***
Block 3 (vs. 1)	0.766	0.149	5.13	<.001	2.15	[0.473; 1.058]	***

Note: GLMM: *AC accuracy ~ social group + block + (1 | participant) + (1 | item)*.
Significance codes: '***' $p < 0.001$; '**' $p < 0.01$; '*' $p < 0.05$. N = 51.

LMM predicting Confidence based on Social Group (Experiment 1)

Predictor	β	SE	t	p	95% CI	Sig.
Intercept	2.626	0.047	56.28	< .001	[2.535; 2.718]	***
Group (in vs. out)	−0.049	0.031	−1.61	.109	[−0.110; 0.011]	
Block 2 (vs. 1)	0.084	0.039	2.17	.030	[0.008; 0.159]	*
Block 3 (vs. 1)	0.099	0.038	2.58	.010	[0.024; 0.174]	*

*Note. LMM: confidence ~ social group + block + (1|participant) + (1|stimulus fact). Significance codes: '***' p < .001; '**' p < .01; '*' p < .05*

GLMM predicting Inference Accuracy based on Social Group (Experiment 2)

Predictor	β log odds	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	-0.279	0.282	-0.99	.324	0.76	[-0.843; 0.283]	
Group (in vs. out)	0.204	0.121	1.68	.093	1.23	[-0.036; 0.444]	.
Block 2 (vs. 1)	0.292	0.149	1.96	.050	1.24	[-0.003; 0.589]	.
Block 3 (vs. 1)	0.504	0.15	3.39	< .001	1.66	[0.211; 0.801]	***

Note: Model GLMM: *AC accuracy ~ social group + block + (1 | participant) + (1 | item)*.
Significance codes: '***' $p < 0.001$; '**' $p < 0.01$; '*' $p < 0.05$, '.' $p < 0.1$. N = 44.

LMM predicting Confidence based on Social Group (Experiment 2)

Predictor	β	SE	t	p	95% CI	Sig.
Intercept	2.524	0.062	40.82	< .001	[2.403; 2.646]	***
Group (in vs. out)	−0.010	0.039	−0.27	.789	[−0.087; 0.066]	
Block 2 (vs. 1)	0.069	0.048	1.43	.154	[−0.026; 0.164]	
Block 3 (vs. 1)	0.127	0.048	2.66	.008	[0.034; 0.221]	**

*Note. LMM: confidence ~ social group + block + (1|participant) + (1|stimulus fact). Significance codes: '***' p < .001; '**' p < .01; '*' p < .05*

GLMM predicting Inference Accuracy based on Social Group and Team Source Memory (Experiment 2) ("clean")

Predictor	β log odds	SE	z	p	OR	95% CI	Sig.
Intercept	-0.236	0.296	-0.80	.425	0.79	[-0.817; 0.344]	
Group	0.397	0.139	2.86	.004	1.49	[0.125; 0.670]	**
Source Memory	0.061	0.159	0.39	.698	1.06	[-0.249; 0.371]	
Block 2 (vs. 1)	0.340	0.168	2.03	.043	1.40	[0.011; 0.669]	*
Block 3 (vs. 1)	0.638	0.170	3.75	< .001	1.89	[0.305; 0.972]	***

N = 41, 1221 observations. Model (GLMM): *AC accuracy ~ social group + source memory team + block + (1 | participant) + (1 | item)*. Significance codes: '***' p < 0.001; '**' p < 0.01; '*' p < 0.05, '.' p < 0.1. Source memory for team (dichotomous scoring correct/false). Group with outgroup as reference.

GLMM predicting Inference Accuracy based on Social Group and Team Source Memory (Experiment 1) ("clean")

Predictor	β log odds	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	−0.089	0.339	−0.26	.793	0.915	[−0.754; 0.576]	
Group (in vs. out)	0.269	0.135	2.00	.046	1.308	[0.005; 0.532]	*
Team source memory	0.385	0.169	2.28	.023	1.469	[0.054; 0.715]	*
Block 2 (vs. 1)	0.419	0.165	2.54	.011	1.521	[0.096; 0.743]	*
Block 3 (vs. 1)	0.779	0.172	4.53	< .001	2.178	[0.442; 1.115]	***

*Note. GLMM: AC accuracy ~ social group + team source memory score + block + (1|participant) + (1|stimulus fact). Significance codes: '***' p < .001; '**' p < .01; '*' p < .05*

GLMM predicting Inference Accuracy based on Social Group and Experiment ID (Combined Dataset)

Predictor	β log odds	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	0.076	0.285	0.27	.789	1.08	[-0.483; 0.636]	
Group (in vs. out)	0.299	0.117	2.55	.011	1.35	[0.069; 0.529]	*
Experiment ID	-0.443	0.216	-2.05	.040	0.64	[-0.865; -0.020]	*
Study ID * Group	-0.094	0.170	-0.55	.581	0.91	[-0.427; 0.239]	
Block 2 (vs. 1)	0.395	0.104	3.79	< .001	1.48	[0.191; 0.599]	***
Block 3 (vs. 1)	0.621	0.105	5.94	< .001	1.86	[0.416; 0.826]	***

Note: N = 95. GLMM: *AC accuracy ~ social group + experiment ID + social group x study ID + block + (1 | participant) + (1 | item)*. Group with 'OUT' as reference, experiment ID with Experiment 1 as reference. Significance codes: '***' p < 0.001; '**' p < 0.01; '*' p < 0.05, '.' p < 0.1.

LMM predicting Confidence based on Social Group and Experiment ID (Combined Dataset)

Predictor	β	SE	t	p	95% CI	Sig.
Intercept	2.603	0.048	54.07	< .001	[2.508; 2.697]	***
Group (in vs. out)	−0.028	0.024	−1.15	.248	[−0.075; 0.019]	
Experiment (2 vs. 1)	−0.076	0.051	−1.49	.141	[−0.177; 0.024]	
Block 2 (vs. 1)	0.079	0.030	2.63	.009	[0.020; 0.138]	**
Block 3 (vs. 1)	0.112	0.030	3.78	< .001	[0.054; 0.171]	***

Note. LMM: *confidence ~ social group + experiment ID + block + (1|participant) + (1|stimulus fact)*. Significance codes: '***' p < .001; '**' p < .01; '*' p < .05

GLMM predicting Inference Accuracy based on Social Group with a Novelty Moderator (Experiment 1)

Predictor	β log odds	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	-0.603	0.368	-1.64	.101	0.547	[-1.326; 0.118]	
Group (in vs. out)	0.510	0.240	2.12	.034	1.665	[0.040; 0.981]	*
Novelty	0.303	0.090	3.37	< .001	1.354	[0.127; 0.480]	***
Novelty x Group	-0.100	0.106	-0.95	.342	0.905	[-0.309; 0.107]	
Block 2 (vs. 1)	0.537	0.148	3.63	<.001	1.711	[0.247; 0.826]	***
Block 3 (vs. 1)	0.797	0.151	5.29	<.001	2.219	[0.502; 1.092]	***

Note: GLMM: *AC accuracy ~ source condition x novelty + block + (1|participant) + (1|stimulus fact)*. Significance codes: '***' p < 0.001; '**' p < 0.01; '*' p < 0.05

GLMM predicting Inference Accuracy based on Social Group with a Novelty Moderator (Experiment 2)

Predictor	β	SE	z	p	OR (exp(β))	95% CI	Sig.
Intercept	−0.797	0.336	−2.38	.017	0.451	[−1.455; −0.140]	*
Group (in vs. out)	0.236	0.238	0.99	.322	1.266	[−0.231; 0.703]	
Novelty	0.267	0.094	2.84	.005	1.306	[0.083; 0.451]	**
Novelty × Group	−0.018	0.110	−0.16	.871	0.982	[−0.233; 0.198]	
Block 2 (vs. 1)	0.308	0.150	2.05	.040	1.361	[0.014; 0.602]	*
Block 3 (vs. 1)	0.536	0.150	3.57	< .001	1.710	[0.242; 0.830]	***

Note. GLMM*: AC accuracy ~ social group + novelty + group * novelty + block + (1|participant) + (1|stimulus fact).* Significance codes: '***' p < .001; '**' p < .01; '*' p < .05

Source Memory

Fixed Effects:

GLMM predicting Source Memory based on Inference Accuracy and Social Group (Experiment 1)

	Team Source Memory					
	Estimate (SE)	Z Value	OR	P Value	95% CI	Sig.
Intercept	0.982 (0.19)	5.18	2.67	< .001	[0.611; 1.354]	***
AC Accuracy	0.559 (0.20)	2.79	1.75	.0049	[0.166; 0.951]	**
Social Group	0.040 (0.21)	0.19	1.04	.849	[-0.373; 0.453]	
Group x Accuracy	-0.340 (0.28)	-1.23	0.71	.220	[-0.881; 0.202]	
Block 2	0.176 (0.16)	1.09	1.19	.277	[-0.141; 0.493]	
Block 3	0.247 (0.17)	1.48	1.28	.139	[-0.080; 0.573]	
	Individual Source Memory					
	Estimate (SE)	Z Value	OR	P Value	95% CI	Sig.
Intercept	-0.339 (0.17)	-1.98	0.71	.048	[-0.676; -0.003]	*
AC Accuracy	0.707 (0.17)	4.16	2.03	< .001	[0.374; 1.040]	***
Social Group	0.398 (0.19)	2.11	1.49	.035	[0.029; 0.767]	*
Group x Accuracy	0.521 (0.24)	-2.19	1.68	.029	[-0.987; -0.054]	*
Block 2	0.304 (0.14)	2.19	1.36	.028	[0.032; 0.576]	*
Block 3	0.260 (0.14)	1.85	1.30	.065	[-0.016; 0.535]	

Note. N = 47; observations = 1395. Model: *SM accuracy ~ social group (in vs. out) x AC accuracy + block + (1|participant).* Source group with "OUT" as reference. 'AC Accuracy' as dichotomous correctness of inference trial with 0 (false) as reference. Interaction between AC inference correctness and source group. Significance levels: *** = 'p < .001'; ** = 'p < .01'; * = 'p < .05'.

GLMM predicting Source Memory based on Inference Accuracy and Social Group (Experiment 2 and Combined Dataset)

	Estimate (SE)	Z Value	OR	P Value	95% CI	Sig.
Experiment 2						
Intercept	1.006 (0.18)	5.45	2.73	< .001	[0.644; 1.367]	***
AC Accuracy	-0.021 (0.19)	-0.11	0.98	.911	[-0.389; 0.347]	
Social Group	-0.087 (0.20)	-0.44	0.92	.658	[-0.471; 0.298]	
Group x Accuracy	0.060 (0.26)	0.23	1.06	.819	[-0.455; 0.575]	
Block 2	-0.032 (0.16)	-0.20	0.97	.839	[-0.342; 0.278]	
Block 3	-0.144 (0.16)	-0.91	0.87	.362	[-0.456; 0.166]	
Combined Dataset						
	Estimate (SE)	Z Value	OR	P Value	95% CI	Sig.
Intercept	1.241 (0.15)	8.12	3.46	< .001	[0.941; 1.540]	***
AC Inference	0.254 (0.14)	1.86	1.29	.062	[-0.013; 0.522]	
Social Group	-0.029 (0.14)	-0.20	0.97	.843	[-0.310; 0.253]	
Group x Accuracy	-0.137 (0.19)	-0.72	0.87	.470	[-0.509; 0.235]	
Block 2	0.069 (0.11)	0.61	1.07	.544	[-0.153; 0.291]	
Block 3	0.042 (0.11)	0.37	1.04	.714	[-0.182; 0.266]	
Experiment No.	-0.458 (0.15)	-3.11	0.63	.001	[-0.746; -0.170]	**

Note. Experiment 2: N = 41, observations = 1221; Combined: N = 88; observations = 2616. Model Experiment 2: *SM accuracy ~ social group (in vs. out) x AC accuracy + block + (1|participant).* Model Combined: same, with added *study ID* predictor. Source group with "OUT" as reference. 'AC Accuracy' as dichotomous correctness of inference trial with 0 (false) as reference, Experiment No. with 1 as reference. Interaction between AC inference correctness and source group. Significance levels: *** = 'p < .001'; ** = 'p < .01'; * = 'p < .05'.