LUNDS UNIVERSITET

Department of Psychology
*Bachelor's Thesis*

# Effekten av sociala grupper på kunskapsinlärning genom minnesintegration

# The effect of social groups in factual knowledge acquisition through memory integration

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## Abstract

Memory integration is a memory function that promotes knowledge acquisition through the combination of information across overlapping events. This study investigates the influence of ingroup and outgroup sources on memory integration. Participants (N = 61) selected ingroup teammates and outgroup opponents to present them information in a knowledge extension task, driven by memory integration mechanisms. In the encoding phase, participants learned paired stem facts that were either presented by an ingroup or an outgroup source, from which they could later infer novel integration facts. In the testing phase, participants were presented with either a true or false version of each novel integration fact, and asked to judge the veracity of these. Participants' responses could be divided into hits, correct rejections, false alarms and misses. The results showed that the amount of hits were equal for information presented by both social groups, but false alarms were more common for information presented by ingroup members. Participants also had more difficulty discriminating hits from false alarms, and were more likely to accept information presented by ingroup sources, irrespective of its actual veracity in the ingroup condition. Finally, the results on source memory were insignificant, although there was a tendency for participants' source memory to be better for ingroup members.



*Keywords:* Ingroup, outgroup, associative inferences, source memory, memory integration

## Sammanfattning

Minnesintergration är en minnesfunktion som bidrar till kunskapsinlärning genom att kombinera information från överlappande event. Denna studie undersöker påverkan av olika källor, ingrupp och utgrupp, på minnesintegration. Deltagarna (N = 61) valde medlemmar till sitt eget lag, ingruppen, och motståndarlaget, utgruppen. Medlemmar från båda lagen presenterade information till deltagarna genom ett “knowledge extension task”, baserat på mekanismer av minnesintegration. I inkodningsfasen lärde sig deltagarna fakta som presenterades av antingen en ingrupps- eller utgruppsmedlem, som de sedan kunde bilda “novel integration facts” från. I testfasen presenterades deltagarna för antingen en sann eller falsk version av dessa fakta, som de ombads att bedöma sanningshalten av. Svaren indelades i träffar, korrekta avslag, falska positiva och missar. Resultatet visade att träffar var lika vanligt förekommande oavsett vilken social grupp som presenterat faktan, medan falska positiva var vanligare för information som presenterats av ingruppsmedlemmar. Det var även svårare för deltagarna att urskilja träffar från falska positiva, och de var mer benägna att acceptera information från ingruppskällor oavsett om det var sant eller inte. Slutligen var resultaten för källminne insignifikanta, däremot fanns en tendens för deltagarnas källminne att vara bättre för ingruppen.



*Nyckelord:* Ingrupp, utgrupp, associativa inferenser, källminne, minnesintegration

# The effect of social groups in factual knowledge acquisition through memory integration

## Memory

Memory is a function of great significance that is closely tied with our identity, without which we could not perform basic everyday activities. According to Nadel et al. (2012), memory formation begins by first experiencing an event of which some details, such as certain people or objects, are encoded. These encoded objects go through a series of consolidation processes to form a memory trace in long-term memory. However, these consolidated memories are not permanent nor immune to alteration. When a memory is reactivated by a cue, it will be susceptible to change and may become strengthened, weakened or even erased during reconsolidation (Nader et al., 2000). Additionally, during reactivation of a memory it will be recalled in dismembered parts, rather than in its entirety. These parts of memories therefore need to be reconstructed, which is a factor in explaining why reconsolidation may not be entirely accurate (Nadel et al., 2012).

Tulving (1972) differentiated between two different memory systems, episodic and semantic memory. Episodic memory is defined by its ability to make us consciously re-experience past events from a first person perspective. Semantic memory instead enables recollection of factual knowledge, without necessarily knowing when, where or how these facts were learned (Tulving 1985). The hippocampus is the main region for encoding and storing episodic memories, and the neocortex is the main region for semantic memories. However, during consolidation episodic memories are transferred to the neocortex (Schlichting & Preston, 2015). Tulving (1972) explained that episodic memories are tied to spatiotemporal context, i.e. the time and place, as well as mental state of the memory. These memories are stored and organized based on their context. For example, two distinct events with different people that occur in the same physical context will be stored more closely than two events that have the same people but in different places. The other type of memory, semantic memory, is a memory system organized by meaning instead of context (Tulving 1972).

The distinction between episodic and semantic memory has been highly influential in the memory literature. However, recent studies have shown that the boundaries between these two systems are not as distinct as previously thought. For example, the episodic memory system seems to have an important role in knowledge acquisition and generalization. This has been seen in studies showing the involvement of the hippocampus in tasks that require memory integration, such as associative inferences and categorization tasks (Zeithamova and Bowman, 2020).

**Memory integration & memory inferences**

Memories that overlap can be integrated to facilitate generalization to entirely new situations. An example of memory integration by Schlichting & Preston (2015) is that if one sees a woman walking her dog in the park and the next day sees a man walking that same dog, the memories of the man and woman can become integrated in a single memory representation even though they were never seen together. This would allow one to infer a relationship between the woman and man in the future. This type of integrated memory representation is crucial for knowledge update and extension (Schlichting & Preston, 2015).

When related memories have overlapping neural representations, memory networks are formed which map these events and may facilitate the encoding of novel information. This entails that the processing of novel information interacts with prior knowledge (Schlichting & Preston, 2015). The brain regions supporting these memory integration mechanisms are mainly the hippocampus (Bunsey & Eichenbaum, 1996) and the medial prefrontal cortex (DeVito et al., 2010; Koscik & Tranel, 2012), challenging the division of labor between hippocampus and neocortex regions for episodic and semantic memory respectively. The hippocampus will reactivate stored memories which overlap with novel information through pattern completion mechanisms (Zeithamova et al., 2012; Preston & Eichenbaum, 2013), allowing old memories to be integrated with new information. This process is essential for the creation of new knowledge and for the update of old knowledge.

In the laboratorium, memory integration has been investigated in multiple ways, one of which is with inference paradigms, such as the associative inference task (Varga and Bauer, 2017). Varga and Bauer formulated a paradigm with stem facts, from which novel integration facts could be derived. Each novel integration fact (AC) could be derived from two stem facts (AB and BC). Participants are first shown the AB stem fact, and then the BC stem fact, which both have the common denominator B. The participant should then be able to infer that A and C are related.

There are two different ways that the novel integration facts (AC) can be inferred. According to the integrative encoding theory, participants retrieve the AB memory at the time of BC encoding and form an integrated memory representation involving the ABC stems

(Zeithamova & Preston, 2017). In contrast to this, the novel integration fact (AC) can also be inferred at the time of test through flexible retrieval. In this case, participants retrieve both the AB and the BC memory when they are asked to judge the novel integration facts, meaning that the ABC stems are never integrated in the participants memory (Carpenter & Schacter 2018a; 2018b). At the moment, the different conditions that affect the way participants make associative inferences are unclear, but there is neuroimaging evidence supporting both theories (Zeithamova & Preston, 2017; Bunsey & Eichenbaum, 1996).

**Source memory**

Recent studies have suggested that a consequence of integrating information in memory is a loss in source memory. For example, Carpenter & Schacter (2018a; 2018b) found a connection between making successful associative inferences and source monitoring errors. They argue that the same flexible retrieval mechanism that supports successful inference making produces source misattributions as a consequence, because one mistakenly combines contextual details from overlapping events. They tested source memory in different conditions, and found that the source misattribution errors only occurred after successful inferences. This was compared to conditions where the source memory was tested both before and after inference making, but when the inferences were unsuccessful. In essence, this means that the source monitoring errors seemed to be dependent on making successful inferences.

However, others have not found evidence of this connection between successful inferences and source monitoring errors. In a study by de Araujo Sanchez & Zeithamova (2023) integrative encoding and the following generalizations participants made were investigated. In the article the authors argue that when a person infers information from an integrated memory, i.e. makes a generalization, they may be more prone to making source monitoring errors. However, the results of their study showed that making successful generalizations did not necessarily result in such source monitoring errors. Furthermore, Boeltzig et al. (2023) also investigated memory inferences and similarly found no connection between making successful inferences and source misattribution.

To successfully determine the source of information from a memory, one first has to sufficiently encode the information. By, for example, not fully paying attention, being stressed or being under the influence, one's perceptual and reflective processes will be disturbed and thus partly inhibit the encoding process. This will lead to an inability to later attribute this perceptual and contextual information to the memory, which would be necessary for the source monitoring judgement processes. This can lead to misattribution, which is defined as attributing a memory to the wrong source, which can occur during false recall and false recognition (Schacter, 2022).

Our level of source monitoring can affect the amount of details we remember about the source of a memory. Source monitoring is explained by Johnson et al. (1993) as the judgements one makes about the source from which novel information is learned. This process is crucial for being able to differentiate memories from different situations. According to Johnson & Raye (1981), external source monitoring is the process of discriminating between different external sources, such as what one has heard or seen.

Johnson and colleagues (1993) further explain that source monitoring essentially works by attributing characteristics to memories, of which some of the most important are perceptual, contextual, semantic and affective information. The process of source monitoring can be rapid and subconscious (heuristic judgement), but may at times also be a slower, conscious and strategic process (systematic judgement), where one needs to retrieve other supporting memories and use logical reasoning. Although systematic judgement processing is not used as often, both types may be used simultaneously. When determining a source, memories may be attributed with different degrees of specificity. For example, one may at times remember who said what as well as when and where, but at other times only remember what someone said without remembering any other contextual information.

**The effects of social contexts on memory**

Our ability to recall memories and their source is affected by external sources. Social networks can affect both of these aspects, and what is remembered is often dependent on the social context like conversational dynamics and one's relationship with the "audience", i. e. the people listening (Hirst & Echterhoff, 2011). For example, we may tailor a retelling of a memory to fit what we believe the audience wants to hear, referred to as "audience tuning" (Hirst & Echterhoff, 2011). Audience tuning can also shape subsequent recalling of that memory in the storyteller; there are studies showing that adjusting a message about an individual to fit the audience's attitude towards them (positive or negative) has a lasting impact on the communicator's own memory and evaluation of that subject (Higgins & Rholes, 1978). Another example of how social contexts shape memory is when a memory, or an alteration of a memory, is spread from one person to another, for example from a speaker to a listener. This phenomenon is referred to as social contagion (Hirst & Echterhoff, 2011). Social contagion is usually amplified in situations where the informant is a friend or partner rather than a stranger. People are more influenced by others' incorrect answers when recalling words when they were with a friend group, compared to with strangers, and it is suggested that this is because a person is more likely to confuse one's own memories with another's when that person is a friend (Peker & Tekcan, 2009). People are also more likely to report their partner's memories as their own when that topic had previously been discussed with them (French et al., 2008). Social contagion has also been found to occur more when the source of the information is credible or neutral, compared to non-credible (Andrews & Rapp, 2014). Andrews & Rapp (2014) further argue that more false memories are accepted because one is misattributing the source of the memory to be oneself instead of someone else, further explained by their finding that these source misattributions were also made more often with the credible and neutral sources.

External resources such as social contexts and the relationship with the source can shape our memories in different ways, and it may result in a lower accuracy of a memory. It is possible then, that the way we categorize people into social groups has an effect on memory.

**Ingroups & outgroups**

According to Liberman and colleagues (2017) social categorization is a way for us to organize our knowledge of people in our brains, and evidence suggests it is an automatic process. The ability to group things together to generalize knowledge and apply that knowledge in novel situations is an important part of human cognition, because it helps us inform and make inferences that guide our thoughts and decisions. We can see this type of social categorization across cultures and even in infants (Liberman et al., 2017; Mahajan & Wynn, 2012). For example, children will seek novel information from a member of their own group rather than someone else, and they also tend to expect members of their own social group to avoid causing harm to each other (Liberman et al., 2017). It is believed that this categorization stems from a survival instinct because living in groups has historically been a more successful survival strategy for the individual. Many of our evolutionary adaptations are a reflection of our tendency to live in groups, such as cooperation and other social skills (Brewer, 2001). According to Mahajan and Wynn (2012), this social categorization is what creates the feeling of "us" and "them", because we group ourselves with people like us, and group together people unlike us. These similarities can be personality, cultural background or physical appearance, and we tend to be more attracted to people because of our similarities to them (Mahajan & Wynn, 2012). This "us" and "them" phenomenon is one of the most important factors in social categorization, and are often referred to as "ingroups" and "outgroups".

**Differing memory for ingroups & outgroups**

It is well-known that people tend to have a preference for ingroup members compared to outgroup members; often called ingroup bias. The preference for ingroup members can affect our cognitive abilities such as perception, attention and memory. For example, in a previous study done by Jeon and colleagues (2021), a "group-reference effect" was found, which means that the encoding of a memory is enhanced when the information is related to a person's ingroup. It is a development on the "self-reference effect" which has been studied extensively, and it is believed that these effects are related because information about one's ingroup relates to information about oneself. The same study also found that simply presenting an item together with self-relevant information can enhance memory for that item (Jeon et al., 2021). The effect of social groups on memory can also be seen in facial recognition studies. In these studies participants often remember faces better and with more detail when they are from an ingroup member compared to an outgroup, specifically when the groups are based on race (Malpass & Kravitz, 1987). This effect has been replicated many times and is often referred to as the own-race bias (ORB) (Meissner & Brigham, 2001) or the cross-race effect (CRE) (Young et al., 2012).

This own-race bias or cross-race effect in face memory suggests that there is a difference in the way we process faces, which would mean that the effect has a neurological basis. Some studies have used an EEG and looked at brain waves while participants viewed different faces. A study by Levin (2000) argues that the bias exists because one attends to visual cues related to race over personalized characteristics when identifying a cross-race individual. Other studies have expanded on this concept; Ito and colleagues (2004) found that the amplification of certain brainwaves (specifically N200) were larger for ingroup members, suggesting that ingroup faces are processed to a greater extent. The experiments were conducted on (self-identified) white people looking at either white or black faces, and the authors mention that this difference in processing is consistent with earlier evidence for the behavioral components of the ORB/CRE (Ito et al., 2004). Other studies have seen similar neurological effects even when the groups are based on arbitrary traits (Ratner & Amodio, 2013). Moreover, studies using fMRI have also found that the fusiform face area (FFA) is activated more when viewing ingroup faces (Van

Bavel et al., 2008), and that this change in activation correlates with better memory for ingroup faces (Golby et al., 2001).

Social categorization of groups seems to happen very early in perceptual processing and shapes subsequent attention and depth of processing which operate beyond conscious awareness. Both the results of event-related potentials and fMRI studies align in their indications of this neurological basis of a group-based memory bias, although the research is still ongoing.

Not only do social groups affect how we remember information about an individual, such as details of their face, but the relationship with whom we are discussing our memories can also affect the accuracy of both the memory itself and its source. Memory seems to be more accurate for information about ingroup members, however, little is known about how these ingroup biases extend to more flexible memory mechanisms, such as associative inferences.

**The effect of ingroup and outgroup sources on associative inferences**

A previous study has investigated associative inferences and social groups. Boeltzig and colleagues (2023) conducted a series of experiments to investigate differences in inference accuracy for information presented by ingroups and outgroups. Pictures of neutral objects were paired with a person (ingroup or outgroup) and with a context (a background). The authors found that more correct inferences were made when the information was presented by ingroups. It was discussed that the reason for this may be that a higher level of source monitoring is applied to the outgroup individuals since the participants trust them less, leaving reduced attentional resources to memorize the stimuli that they presented. This result was found when the participants had two individuals on each team (their own and the opposing team). However, no such effect was found when there was only one person in each group presenting the information, which indicates that the effect is dependent on a group situation and not just one individual which the participant likes compared to one that they dislike.

**Our study: method and purpose**

This study will further explore the associative inferences in memory made with information presented by ingroup vs. outgroup members, and if there is a difference depending on the informants' group status. In the previous study by Boeltzig and colleagues (2023), the authors used arbitrary associations between random objects that could not be accepted or rejected on the basis of previous knowledge. Here we employed a knowledge extension task with fact sentences that participants can reject or accept by making incidental inferences (Varga and Bauer, 2017). This incidental task entails that participants were not specifically instructed on how they are supposed to combine the information provided, but they are expected to make the correct inferences subconsciously. Our paradigm creates a more naturalistic way of investigating if information provided by ingroups have privileged access to our knowledge database.

We created a knowledge extension task where participants had to judge the veracity of novel integration facts by inferring information from two stem facts. The facts were made in the AB/BC/AC format. This means that AC should be possible to infer from AB and BC because of the common denominator B. The AB/BC/AC format has previously been used in multiple studies as a type of associated inference task (Boeltzig et al., 2023; Preston et al., 2004; Varga & Bauer, 2017; Zeithamova & Preston, 2010). Participants were presented with stem facts from different subject domains, presented by either an ingroup or an outgroup member. After learning, participants were presented with correct and incorrect novel integration facts and were asked to judge their veracity. An example of a pair of stem facts are “Apple seeds are called pips” (AB) and “Cyanide is found in pips” (BC). From this information, the participant should be able to infer that either “Apple seeds contain cyanide” (AC) is true, or that “Apple seeds contain arsenic” (AC) is false. We also decided to have two individuals in each group (excluding the participant) because of the finding by Boeltzig and colleagues (2023) that the effect is dependent on a group situation (two or more individuals) and not just individuals which the participants like or dislike.

Additionally, we also investigated source memory. Given that previous studies have shown lowered source memory for ingroup members and source misattribution errors after correct inferences, it is of interest to explore source memory after inference making for information provided by ingroups and outgroups.

This study aims to gain a deeper understanding of the inferences we make in our daily lives and if they are affected by different social groups, in turn shaping people's beliefs and knowledge systems. If memory integration is facilitated to a greater extent for ingroup information, it could contribute to biased information being spread among ingroup members, which would maintain and further reinforce contrasting beliefs between groups.

**Predictions**

Given the previous findings of Boeltzig et al. (2023), we predicted that participants will make more hits when the information has been provided by an ingroup member, meaning that they are more likely to say that correct novel integration facts (AC) are true when the corresponding stem facts (AB and BC) are presented by an ingroup face (H1). Additionally, we will also test the possibility that participants make more false alarms when the information is provided by an ingroup member, meaning that they are more likely to say that incorrect novel integration facts (AC) are true when the corresponding stem facts (AB and BC) are presented by an ingroup face (H2). Having ingroup members present information may result in more inferred information being accepted, even if it is not correct, because we attribute some sort of trust to people we like. To follow up these predictions, we will look at memory discrimination d' and response bias C (Snodgrass & Corwin, 1988) as a function of social group source. The d' value is a way of telling if participants are good at discriminating hits from false alarms; a small d' value indicates that discrimination is low. The C bias is a tendency to answer "true" more often; a lower C value indicates a lower, more relaxed criterion for saying "yes" (Snodgrass & Corwin, 1988). Additionally, we also predict that for the ingroup participants will answer with higher confidence and have shorter response times (H3). Finally, given previous research on social contagion (Andrews & Rapp, 2014), we predict that source memory will be lower for ingroup members (H4), because source monitoring resources are usually lowered for ingroup information.

## Method

### Participants and Design

The study was conducted with a quantitative method, where the participants' answers were recorded in a computer program and later analyzed for statistical significance in Jamovi (Version 2.5) (The Jamovi Project, 2024). 70 participants were recruited, of which 9 were excluded, bringing the total sample to 61 participants (22 men, 39 women, ages 19-57 ($M = 23.6$, $SD = 5.01$)). All participants were given a gift card of 100 SEK on completion of the experiment. One participant was excluded due to them not finishing the experiment. Two participants were excluded because they did not prefer the ingroup members over the outgroup members in the beginning of the experiment. Six participants were excluded due to their memory discrimination (d') value being lower than 0, showing that they did not learn anything during the experiment. The sample consisted mostly of students from Lund University, and since there was no randomization involved in the way the participants were chosen, it is considered a convenience sample. Keeping in mind the limited resources available for this thesis it was deemed unrealistic to use a random sample method even though it would ensure a higher external validity. Because of the short timespan of the study, a convenience sample was determined the most effective method in order to obtain a large enough sample; since the sample size in Boeltzig et al. (2023) was around 60 people, the chance of finding similar effects would increase by having a similar or larger sample in this experiment.

**Ethical considerations**

This study was conducted in accordance with the Swedish Act concerning the Ethical Review of Research involving Humans (2003:460). It does not require specific ethical review because: (1) it does not deal with sensitive personal data, (2) it does not use methods that involve a physical intervention, (3) it's purpose is not to affect the participant physically or mentally, (4) it does not use methods that pose a risk of mental or physical harm, (5) it does not study biological material taken from a living human that can be traced back to that person. All participants were asked to read and agree to a text about informed consent before starting the experiment, in which it was stated that their participation is completely anonymous and they are free to quit the study at any point, if they wish.

**Material**

80 paired stem facts and 40 novel integration facts were constructed, however one of the pairs was excluded from the data because of a presentation error during the experiment. The facts were chosen to be unfamiliar enough so that the participants would not know most of them beforehand. They were also from different subject domains such as movies, geography, animals and plants, the human body etc. The facts were written in the AB/BC/AC format meaning that each fact had three parts: A, B and C. The point was for the participant to be able to infer that A and C are connected, from first seeing AB and then BC. They were presented with both AB and BC, and when presented with AC they were asked if it was true or false. Both true and false versions of each novel integration fact were also created. The facts were created in pairs, to avoid that the false answers would be correctly recognized as false simply because the participant had not seen the word that was being presented before. Below follows an example of a pair of sentences:

**Table 1.**

*Paired Example Sentences*

| | | |
|---|---|---|
| **Stem 1 (AB)** | Apple seeds are called pips | Lettuce is a leafy vegetable |
| **Stem 2 (BC)** | Cyanide is found in pips | Arsenic is found in leafy vegetables |
| **Novel integration fact (AC)** | Apple seeds contain cyanide (true)<br>Apple seeds contain arsenic (false) | Lettuce contains arsenic (true)<br>Lettuce contains cyanide (false) |

The sentence “Apple seeds contain arsenic” could not be identified as false simply because the participant knew that they had not seen the word “arsenic” before, because they had seen it in the other part of the pair: “Arsenic is found in leafy vegetables”.

Participants selected their teammates and opponents from six female faces obtained from the Face Research Lab London Set (2017), the same ones that were used in Boeltzig et al. (2023). Participants were able to choose characteristics for their teammates and opponents from six categories; political views, study major, eating habits, sports, hobbies, and music, with five possible choices for each category. The categories were also the same as in the Boeltzig et al. (2023) article, but the different available attributes for each category were chosen subjectively by the authors.

**Procedure**

At first, the participants were asked to read and agree to the information about consent, and had the opportunity to ask questions if anything seemed unclear. Additionally, they were asked about their age and gender which was then collected with their participant number as well as their acceptance of the information on consent. They were then asked to take a seat in front of one of the computers and start the experiment, which contained all further instructions. The software that was used to present the stimuli and record the participants’ data was E-prime 3.0 (Psychology Software Tools, Pittsburgh, PA).

Firstly, they were asked to make a team and an opposing team to compete in a memory game. They chose two profile pictures for the teammates and opponents respectively, along with their personal characteristics from six categories (Figure 1a). After this, a liking measure was administered where the participants were asked how they felt about the members of the different teams (Figure 1a). This was done as a manipulation check to see if the participant actually preferred the members of their team (ingroup) as opposed to their opponents (outgroup). If they did not, it is possible that they did not understand the task correctly and we could therefore remove their data from the analysis.

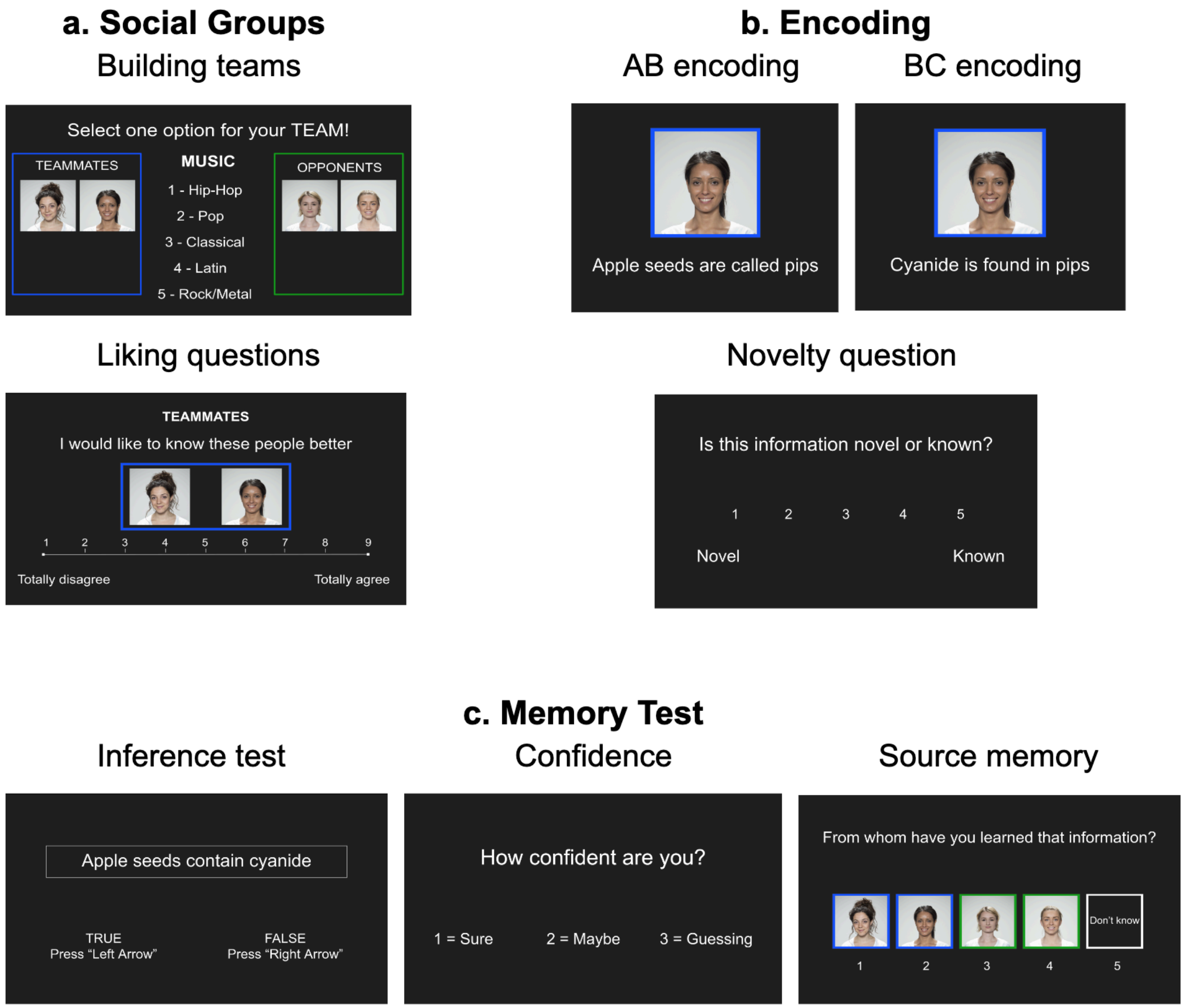
The actual memory task was then divided in two blocks. Each block contained 40 stem facts presented by both the participants' teammates and their opponents. The sentences were presented for seven seconds each (Figure 1b). After each sentence the participants were asked to rate how novel the information was for them on a scale of 1-5, responding by pressing the corresponding button on the keyboard (Figure 1b). This was to confirm that there was no difference in how much of the information presented by the ingroup and outgroup members the participants knew beforehand, since this would have distorted the results. They had three seconds to respond and if they did not press any button within this time the program would automatically move on to the next sentence. The paired stem facts were separated by 2-4 other facts to create a temporal distance that was still short enough so that the participants could realize that the paired facts were related. This means that the related BC fact would appear within 2-4 sentences of the AB fact, as previously done by Varga & Bauer (2017).

After the presentation of the 40 sentences, participants were asked to evaluate the veracity of 20 novel integration facts that consisted of information that could be derived from the previously seen stem facts. They were asked to press a button on the keyboard for either “true” or “false”, followed by how sure they were of their answers (“guessing”, “maybe”, or “sure”), and lastly who out of their teammates and opponents had presented them with this information (Figure 1c). The option “don’t know” was available for the faces but not the other questions. There was no time limit on these questions. This procedure was repeated in block two, after which the participants were asked to choose their teammates and opponents again to confirm that they remembered who they chose, and then concluding with the liking measure questions one more time (Figure 1a).

Before the participants left, they were also asked to fill out a paper containing all of the correct novel integration facts and check a box if they knew the information from before the experiment. This allowed us to measure what participants may already have known before the experiment.

**Figure 1.**

*Overview of the experiment*




**a. Social groups:** One alternative is chosen for each team, for each of all six categories. Five questions about the participants' opinions of each team are asked. **b. Encoding:** Stem facts are shown from all members, after each fact the participant is asked how novel or known it is to them. **c. Memory test:** The novel integration facts are shown, and after each fact the participant rates their confidence as well as answers who they remember said the information.

## Data analysis

The data was transferred to and analyzed in the statistical program Jamovi (Version 2.5) (The Jamovi Project, 2024). Firstly, some initial checks on the data were made, such as making sure that participants remembered who they chose for their teams and opponents, and that they liked their teammates more than their opponents (confirmed with a paired t-test). Furthermore, the novelty data was checked to ensure that participants did not know more of the facts from one of the groups beforehand.

Secondly, the memory task was analyzed. Responses that were either too slow (>15000ms) or too quick (<700ms) were excluded from the analysis. According to the Signal Detection Theory (Snodgrass & Corwin, 1988) there are four possible response types: “Hit” (responding ‘true’ to true sentences), “False Alarms”, or “FA” (responding ‘true’ to false sentences), “Correct Rejection” or “CR” (responding ‘false’ to false sentences) and “Miss” (responding ‘false’ to true sentences). A Factorial Repeated Measures ANOVA was conducted with the within subject factors group (ingroup vs. outgroup) and response type (hits vs. FA).

Next, the memory discrimination d’ and response bias C for each participant was calculated. The d’ value is calculated by subtracting the amount of false alarms from the hits (d' = (Hit - FA). A small d’ value indicates that people are not discriminating hits from false alarms. The C bias is also calculated; (C = –0.5(Hit + FA). An increase in hits and false alarms reflects a more liberal criterion for saying “yes”, in which case the midpoint for the C value will shift to the right. If the observer uses a stricter criterion the midpoint for the C value will shift to the left (Snodgrass & Corwin, 1988). A paired-sample t-test was used to contrast d’ and C for ingroup and outgroup sources.

Next, the mean response time and confidence of all response types were calculated and contrasted between groups with Factorial Repeated Measures ANOVAs, to investigate how the informants group status affected response times and confidence responses. The ANOVA had 2x4 levels where the group was either ingroup or outgroup and response type was either hit, false alarm, correct rejection or miss. The answer scale on confidence was reversed (1= sure, 2 = maybe, 3 = guessing), meaning that low values were interpreted as high confidence. Post Hoc tests were conducted with Tukey corrections.

Finally, the source memory was analyzed. Two source memory measures were taken into account: source for persona (remembering the right person) and source for team (remembering the right team regardless of which individual it was). Source memory was investigated with two Factorial Repeated Measures ANOVAs, for persona and team respectively, with the factors group (ingroup vs. outgroup) and all four response types.

Beforehand, an alpha value of $p < .05$ was chosen, meaning that the results of all analyses would be considered significant if the risk of the effect being a product of chance is less than 5%.

## Results

### Liking Results

First, the liking questions were analyzed to see if participants reported liking the ingroup more than the outgroup. As expected participants reported liking the ingroup members more compared to the outgroup, both before and after the experiment (Ingroup before: $M = 7.616$, $SD = .839$; Outgroup before, $M = 3.744$, $SD = 1.19$; Ingroup after: $M = 7.125$, $SD = 1.00$; Outgroup after: $M = 4.436$, $SD = 1.28$). Liking of ingroup vs. outgroup before (paired t-test): $t(60) = 19.051$, $p < .001$, $d = 2.439$. Liking of ingroup vs. outgroup after (paired t-test): $t(60) = 11.093$, $p < .001$, $d = 1.420$. Both tests were significant, meaning that the manipulation check worked.

### Novelty Responses During Encoding

Secondly, the reported novelty of the stem facts were compared between groups with a paired t-test: $t(60) = .919$, $p = .362$, $d = .118$ (Ingroup: $M = 2.424$, $SD = .3772$; Outgroup: $M = 2.360$, $SD = .3665$). The test showed no significant difference in reported novelty between the groups, meaning that any differences between groups was not due to differences in how much participants knew previously from either group.

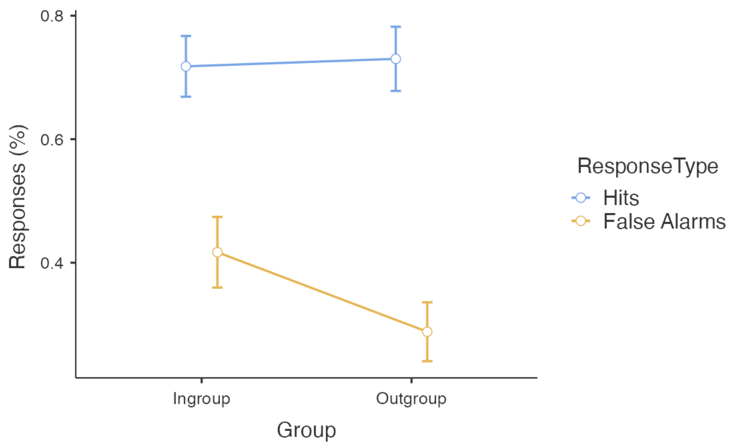
### Memory Performance for the Novel Stem Facts

Next, we calculated an average of correct responses to the novel integration facts, and performance was $M = .678$ ($SD = .114$), meaning that participants on average answered correctly on 67.8% of the true or false questions. This is significantly higher compared with what participants report knowing beforehand ($M = .140$, $SD = .082$). This shows that participants actually learned sentences during the experiment and that most of the facts were previously unknown to them. Reported previous knowledge compared with correct answers (paired t-test): $t(60) = –33.303$, $p < .001$, $d = –4.264$.

We then continued analyzing the differences in hit rates and false alarms between ingroup and outgroup informants with a Factorial Repeated Measures ANOVA (Figure 2). A main effect was found of group ($F_{1,\ 60} = 10.9$, $p = .002$, $\eta^2_p = .153$), indicating that participants were more likely to accept information presented by the ingroup, i.e. answering “true” more often than “false”. A main effect of response type was also found ($F_{1,\ 60} = 160.4$, $p < .001$, $\eta^2_p = .728$), meaning that there were overall more hits than false alarms. An interaction effect between the two was also found ($F_{1,\ 60} = 12.2$, $p < .001$, $\eta^2_p = .169$), suggesting that the amount of hits was equal between groups but the amount of false alarms were higher in the ingroup.

**Figure 2.**

*Hits vs. False Alarms*




Amount of responses depending on response type (Hits, False alarms) and group (Ingroup, Outgroup).

Next, the d' value and C bias was calculated and compared for both ingroup and outgroup information. The mean d' value was higher for the outgroup ($M$ = .442) than the ingroup ($M$ = .301), the difference being significant ($t(60) = –3.497$, $p < .001$), $\eta^2_p = –.4477$). This indicates that participants had more trouble discriminating hits from false alarms if the informant was an ingroup member.

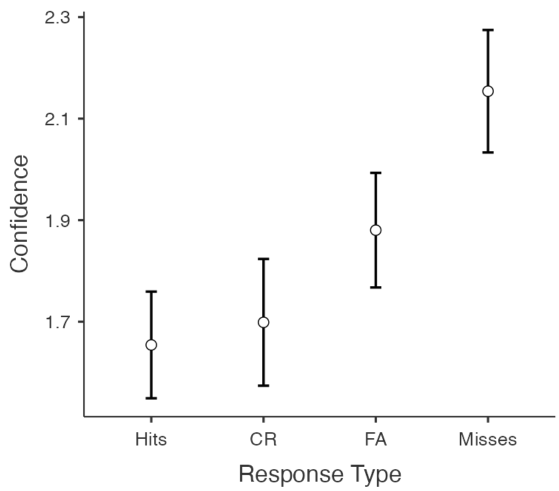
This was further confirmed with the differences in C bias between groups. The C value was lower in the ingroup condition ($M$ = –.567) than the outgroup condition ($M$ = –.509), reflecting a tendency to answer "true" more often when the informant was an ingroup member. This difference was also tested for significance ($t(60) = –3.294$, $p = .002$, $\eta^2_p = –.4218$).

**Confidence Ratings and Response Times**

Furthermore, the confidence ratings and response times for the different response types were analyzed with a Factorial Repeated Measures ANOVA. There was no difference in confidence between groups ($F_{1,\ 47} = .00442$, $p = .947$), but there was a difference in response types ($F_{3,\ 141} = 21.97776$, $p < .001$, $\eta^2_p = .319$) (Figure 3). Post Hoc tests for confidence showed that when participants had a hit they were most confident, followed by correct rejections, false alarms and lastly misses. There was a significant difference between all levels except hits and correct rejections, as well as correct rejections and false alarms. Thus, participants reported being most confident in their answers when they answered correctly, as well as being more confident when they answered a false alarm compared to a miss.

**Figure 3.**

*Confidence ratings*

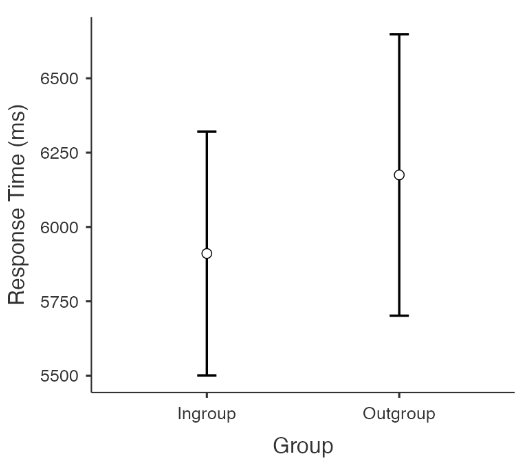



Level of confidence for different response types (CR = Correct Rejections, FA = False Alarms). The scale is reversed; a lower number indicates a higher confidence.

A main effect of group (Figure 4) was found for response times ($F_{1, 46}$ = 4.267, $p$ = .045, $\eta^2_p$ = .085); participants were quicker at responding to questions based on information provided by an ingroup member (Ingroup: $M$ = 5911 ms, $SE$ = 204 ms; Outgroup: $M$ = 6175 ms, $SE$ = 235 ms).

**Figure 4.**

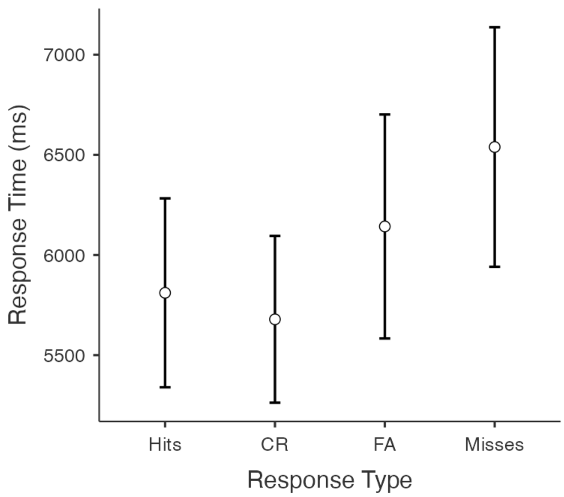
*Response Times Group Difference*



Furthermore, a main effect of response type (Figure 5) was also found ($F_{3, 138}$= 5.155, $p$ = .002, $\eta^2_p$= .101). Post Hoc tests showed that the response time for hits were significantly lower than that for misses ($p$ = .038), and that the response time for correct rejections were also significantly lower than that for misses ($p$ = .012).

**Figure 5.**

*Response Times Response Type Differences*



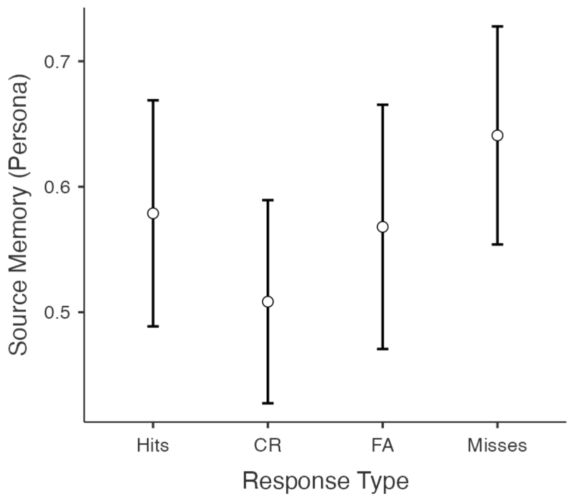

Response times in milliseconds for different response types (CR = Correct Rejections, FA = False Alarms).

## Source Memory

Lastly, some analyses regarding the participants' source memory were conducted. Both the source memory for individual members and the team in general were analyzed with a Factorial Repeated Measures ANOVA (Figure 6). The ANOVA for persona showed no significant effects of group ($p$ = .198), and neither did the ANOVA for team, however, for team the analysis showed a tendency for a main effect of group, indicating that source memory was slightly higher for the ingroup ($p$ = .067). Furthermore, the ANOVA for persona showed a significant main effect of response type ($F_{3, 93}$= 3.10, $p$ = .030, $\eta^2_p$= .091), and Post Hoc tests showed that source memory was significantly higher for misses compared to correct rejections ($p$ = .005).

**Figure 6.**

*Source Memory of Persona and Team*




Source memory for persona, for all response types (CR = Correct Rejections, FA = False Alarms).

## Discussion

The aim of this study was to investigate factual knowledge acquisition through memory integration, specifically the mechanism of associative inferences, and if different social groups would affect the accuracy of these inferences. Previous research (Boeltzig et al., 2023) has found that ingroup information facilitates more accurate inferences, but these effects were not confirmed in this study. Instead, the results indicate that we are more trusting of people in our ingroups, and not as critical of the information they provide, rather than being more accurate in our judgement of it. We tested both the prediction that participants would make more hits (answering 'true' on true statements) for the ingroup condition, and that they would make more false alarms (answering 'true' on false statements). The amount of hits were not significantly different between groups, but the amount of false alarms were significantly higher for the ingroup. This reflects a tendency to accept more false information as true when that information is provided by a person which the participant identifies with. This was further corroborated with the results on the d' value and C bias. The d' value was lower for the ingroup condition, meaning that participants had more difficulty discerning between a true positive (hit) and a false positive (FA). This is also consistent with the results on the C bias, which indicated that participants had a more liberal criteria to answer "true", independent of the actual value of the answer, in the ingroup condition. In essence, these results indicate that people are more likely to accept false information if they make inferences based on information provided by an ingroup member, rather than an outgroup member.

The effects found in this study can be applicable to real life. For example, it may be a contributing factor to confirmation bias: the phenomenon that people seem more likely to accept information when it confirms their own beliefs (Frost et al., 2015). It is known that people tend to favor ingroup members in many different ways, and based on this study, this favorability may also extend to information that is given from one's ingroup. The fact that we seem better at remembering false information provided from the ingroup can be concerning since it can increase the spread of inaccurate information within groups, which can lead to greater polarization between groups.

Furthermore, recent research has explored the connection between associative inferences and source memory. This area of research is divided, and some studies have found no connection between the two mechanisms (de Araujo Sanchez & Zeithamova, 2023; Boeltzig et al., 2023), while others claim that making successful inferences lead to source memory errors (Carpenter & Schacter, 2018a; 2018b). It has also been suggested that source memory may be higher for the outgroup because of a higher level of source monitoring toward them (Boeltzig et al., 2023). Complementary, people would then be more likely to make source misattribution errors when the source is credible or neutral (Andrews & Rapp, 2014). This prompted us to also test the possibility that participants would have lower source memory for ingroup members. As mentioned, the results from this study found no difference in hits (accurate inferences) between groups, nor a difference in source memory between the groups. Both source memory for team (only remembering the team but not the individual) and persona (remembering the exact individual) was tested, but neither analyses were significant. Although there were no significant effects for group, there was a trend showing better source memory for ingroup faces in the team condition ($p$ = .067) but not in the persona condition ($p$ = .198). Being able to remember a specific individual may require a higher degree of specificity in memory, compared to only remembering if it was one's own team or the opposing team (Johnson et al., 1993). This could explain why there is a tendency for source memory to favor the ingroup when remembering the team but not a specific team member; it may require less specificity of attributions to the memory and would therefore be "easier" to remember.

Furthermore, there was a significant main effect of response type in the ANOVA for persona, and post hocs showed that source memory was higher for misses compared to correct rejections. This result was unexpected, and based on previous research we have no possible explanation as to why source memory would be higher for misses.

The two sides of inference research argue whether there is a connection between making successful associative inferences and source memory errors, or whether there is not (de Araujo Sanchez & Zeithamova, 2023; Boeltzig et al., 2023). The results on source memory in this study do not seem to support either side. There was no difference between the groups for either successful inferences or for source memory, but there was however a connection between source memory and misses. Since the connection was not found with all unsuccessful inferences (both false alarms and misses), it cannot fully support the hypothesis, but it does suggest there may be some underlying cause and that a connection is not impossible.

The theory that source memory would be higher for outgroups because of more source monitoring resources being allocated to them does not seem to explain our results. However, it is important to note that the finding on source monitoring comes from a study which employed a much more demanding task than our study did (Boeltzig et al., 2023). Deficient attentional resources was not a factor in the same way in our study, since the task itself was easier and participants had more time to execute it. Instead, our results indicated that source memory could instead be better for the ingroup faces, although the p-value was not significant ($p$ = .067). Source memory being higher for ingroup faces would agree with previous theories on memory for in- and outgroups. It is common to remember ingroup information better, for example ingroup faces (Malpass & Kravitz, 1987; Levin, 2000; Ito et al., 2004; Ratner & Amodio, 2013; Golby et al., 2001) and other information that relates to one's ingroup (Jeon et al., 2021). It is possible that these effects extend to the knowledge extension task as well, and that the reason that participants showed a tendency to remember the ingroup better when making hits and false alarms is simply because ingroup information tends to be remembered better in general.

Moreover, it was hypothesized that confidence would be higher and response times would be shorter for the ingroup information. This hypothesis was partially supported; the confidence was not higher for the ingroup but participants were quicker at judging the veracity of the novel integration facts when the corresponding stem facts had been provided by an ingroup member. Participants answering quicker on the questions they are more confident in would be a reasonable correlation, which makes these results quite contradictory.

Additionally, results from the liking measure confirm that participants liked their teammates more than their opponents, both before and after the experiment. The memory effects are therefore applicable to in- and outgroups since people tend to prefer their ingroup over their outgroup. Furthermore, there was no difference between the groups in the amount of information that participants rated as known. This ensures that any effects found in the amount of correct answers was not due to participants knowing more of the facts from one group. Some additional analyses on response times and confidence can also further confirm the validity of the material. Participants were the most confident and the quickest at responding when they answered correctly (hits and correct rejections). They were also the least confident and the slowest when they answered incorrectly (false alarms and misses). This similar pattern between confidence and response times is logical, since being less sure about one's answer would make one take more time to think before answering.

Moreover, the participants' answers were correct on an average of 67.8% of the questions, while they reported knowing only 14% of the facts from before, which indicated that the difficulty of the experiment was at the level we aimed for. It was easy enough so that participants learned something (they answered better than chance), but not so easy that they answered nearly all questions correctly, since any of these extremes would have made it hard to see any effects.

As stated, some measures were taken to guarantee the applicability of these results and the validity of the material itself. However, some sources of error can be identified. Firstly, it is important to note that the material that was constructed (the fact sentences) was made specifically for this study and had not been independently tested before the experiment. They were made on the basis of previous experiments (Boeltzig et al., 2023; Varga & Bauer, 2017), however, some major changes were made. For example, in the study in Boeltzieg et al. (2023), meaningless connections between objects were made instead of factual information, and in Varga & Bauer (2017) participants answered out loud instead of choosing between two set options (true or false). These changes in material could have altered the reliability of the results. The facts were chosen to be unknown, but done so subjectively by the authors, and no pre-testing was done to make sure that they were unknown to the majority of the population. Future studies could replicate this one to further increase the reliability of the constructed material.

Furthermore, the sample in this study can be considered homogenous, since nearly all participants were students at Lund University between the ages of 18–30. This should be taken into consideration when applying the results to a larger population as it may not be representative. Also, many of the participants were studying the area of psychology or other social sciences, which could mean that some of them may have an idea of the purpose and predictions of the study before participation. It is therefore important to factor in the possibility of a social-desirability bias where participants may have manipulated the way they acted during the experiment in accordance with these ideas. The experiment also contained a lot of instructions and it is possible that participants did not read everything carefully and therefore misunderstood the purpose of the experiment. Additionally, the experiment itself was time-consuming and demanding, and we cannot assume that the participants were paying full attention at all times.

Despite these limitations it is important to note that the subjects investigated here are relatively unexplored, and the results of this study can make significant contributions to a divided area of research. The limitations of this study should be considered when conducting future research, and the results could be further supported if the constructed material was to be tested independently as well as with a more diverse sample. Further research about the effect of ingroup and outgroup sources on memory integration should be made to gain further insight within this subject.

One aspect which was not explored in this study was if a stronger ingroup bias, i.e. how much more one prefers the ingroup over the outgroup, can affect memory integration of information presented by said groups. Future research could incorporate this in their analysis to investigate if people who feel a strong sense of belonging with their ingroup as well as hostility toward their outgroup, may integrate memories and make associative inferences differently than those who feel more indifferent toward their social groups.

This study used more naturalistic stimuli than used in previous research (eg. Boeltzig et al., 2023). However, the novel integration facts used in this experiment are objective and do not relate to the participants' personal lives. It would therefore be interesting to develop the stimuli even further to more emotional statements which would perhaps better investigate the real life polarizing of beliefs from different social groups in society.

Additionally, further research on this subject could investigate the difference in the neurological mechanisms that underlie associative inferences. In this study, it is assumed that participants are solving the task by integrating memories (Varga & Bauer, 2017). However, as seen in other research it is also possible to solve an associative inference task by using flexible retrieval mechanisms (Carpenter & Schacter, 2018a; 2018b). Considering the methodology of this experiment, it is not possible to know for sure if the inferences that participants make are due to their memories being integrated or not. It is possible that the informant's group status can affect which of these two mechanisms that will be used to make an inference, and it would be interesting to see if people are more or less likely to integrate memories depending on the source's group status.

In conclusion, this study aimed to investigate memory inferences through a knowledge extension task. It was found that participants were more likely to accept false information as true when they made inferences with information provided by an ingroup member. Source memory was also investigated, but the results showed no significant differences between the groups. However, there was a significant main effect of response type in the persona condition. In the team condition there was a tendency to remember the source better when that person was an ingroup member, although more research needs to be done on the subject to solidify this effect. These mechanisms could underlie phenomena like confirmation bias, and the idea that people seem more likely to accept information when it comes from someone trusted. It is known that people tend to favor ingroup members in many ways, and based on this study, this favorability may also extend to information that is given from an ingroup member. This could increase the risk of inaccurate information being spread within groups, which could in turn strengthen polarized beliefs between groups. The limitations from this study should be considered when developing this area of research further.

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## Appendix

| Pair | Stem 1 (AB) | Stem 2 (BC) | Novel integration fact (AC) |
|---|---|---|---|
| 1 | Apple seeds are called pips<br><br>Lettuce is a leafy vegetable | Cyanide is found in pips<br><br>Arsenic is found in leafy vegetables | Apple seeds contain cyanide (true)<br>Apple seeds contain arsenic (false)<br><br>Lettuce contains arsenic (true)<br>Lettuce contains cyanide (false) |
| 2 | Lee Pace is an actor that plays the character Roy Walker<br><br>Michael Stuhlbarg is an actor that plays the character Larry Gopnik | Roy Walker is a character in the movie "The Fall"<br><br>Larry Gopnik is a character in the movie "A Serious Man" | Lee Pace is acting in the movie "The Fall" (true)<br>Lee Pace is acting in the movie "A Serious Man" (false)<br><br>Michael Stuhlbarg is acting in the movie "A Serious Man" (true)<br>Michael Stuhlbarg is acting in the movie "The Fall" (false) |
| 3 | Honey is acidic<br><br>Avocados are alkaline | Acidic substances have a low pH value<br><br>Alkaline substances have a high pH value | Honey has a low pH value (true)<br>Honey has a high pH value (false)<br><br>Avocados have a high pH value (true)<br>Avocados have a low pH value (false) |
| 4 | Octopus blood contains copper<br><br>Beetle blood contains vanadium | Blood that contains copper is blue<br><br>Blood that contains vanadium is yellow | Octopi have blue blood (true)<br>Octopi have yellow blood (false)<br><br>Beetles have yellow blood (true)<br>Beetles have blue blood (false) |
| 5 | The bone that extends from the hip to the knee is called the femur<br><br>The bone in the outer part of the calf is called the fibula | The longest bone in the body extends from the hip to the knee<br><br>The bone in the outer part of the calf provides support for the lower part of the leg | The longest bone in the body is called the femur (true)<br>The longest bone in the body is called the fibula (false)<br><br>The bone provides support for the lower part of the leg is called the fibula (true)<br>The bone provides support for the lower part of the leg is called the femur (false) |

| Pair | Stem 1 (AB) | Stem 2 (BC) | Novel integration fact (AC) |
|---|---|---|---|
| 6 | Platypuses are egg-laying mammals<br><br>Dunnarts have pouches | Egg-laying mammals are called monotremes<br><br>Animals with pouches are called marsupials | Platypuses are monotremes (true)<br>Platypuses are marsupials (false)<br><br>Dunnarts are marsupials (true)<br>Dunnarts are monotremes (false) |
| 7 | The Pamukkale is a landmark in the Denizli Province<br><br>The Meteora is a landmark in Thessaly | The Denizli Province is a part of Turkey<br><br>Thessaly is a part of Greece | The Pamukkale is a landmark in Turkey (true)<br>The Pamukkale is a landmark in Greece (false)<br><br>The Meteora is a landmark in Greece (true)<br>The Meteora is a landmark in Turkey (false) |
| 8 | Adolf Fredrik was king of Sweden until 1771<br><br>Alexander I was king of Greece until 1920 | The king of Sweden died from eating too much in 1771<br><br>The king of Greece died from an animal bite in 1920 | Adolf Fredrik died from eating too much (true)<br>Adolf Fredrik died from an animal bite (false)<br><br>Alexander I died from an animal bite (true)<br>Alexander I died from eating too much (false) |
| 9 | The sculpture called “Fountain” is made from a urinal<br><br>The sculptures called “The Watchers” are humanoid figures made from bronze | The sculpture made from a urinal is Duchamp’s most popular work<br><br>The humanoid figures made from bronze is Lynn Chadwick’s most popular work | Duchamp’s most popular work is called “Fountain” (true)<br>Duchamp’s most popular work is called “The Watchers” (false)<br><br>Lynn Chadwick’s most popular work is called “The Watchers” (true)<br>Lynn Chadwick’s most popular work is called “Fountain” (false) |
| 10 | Pegmatite is an intrusive rock<br><br>Arkose is a clastic rock | Intrusive rocks are a type of igneous rocks<br><br>Clastic rocks are a type of sedimentary rocks | Pegmatite is an igneous rock (true)<br>Pegmatite is a clastic rock (false)<br><br>Arkose is a clastic rock (true)<br>Arkose is an igneous rock (false) |

| Pair | Stem 1 (AB) | Stem 2 (BC) | Novel integration fact (AC) |
|---|---|---|---|
| 11 | Hurling is an ancient Irish sport<br><br>Sepak Takraw is a sport native to Southeast Asia | The sport Hurling includes players using a wooden stick called a "hurl" to hit a small ball, the sliotar, between opposing goalposts<br><br>The sport Sepak Takraw is a game resembling volleyball but played with a rattan ball using any part of the body except the hands | A sliotar is a ball used in an ancient Irish sport (true)<br>A sliotar is a ball used in a sport native to Southeast Asia (false)<br><br>A rattan ball is used in a sport native to Southeast Asia (true)<br>A rattan ball is used in an ancient Irish sport (false) |
| 12 | Oak trees are deciduous trees that produce acorns<br><br>Pine trees are conifers that produce cones | Deciduous trees that produce acorns are classified as hardwood trees<br><br>Conifer trees that produce cones are classified as softwood trees | Oak trees are hardwood trees (true)<br>Oak trees are softwood trees (false)<br><br>Pine trees are softwood trees (true)<br>Pine trees are hardwood trees (false) |
| 13 | Donna Strickland is a scientist who found a way to create high-intensity laser pulses<br><br>Irwin Rose is a scientist who discovered the ubiquitin-proteasome system | The scientist who found a way to create high-intensity laser pulses was awarded a nobel prize in physics<br><br>The discovery of the ubiquitin-proteasome system was awarded the nobel prize in chemistry | Donna Strickland was awarded a Nobel Prize in physics (true)<br>Donna Strickland was awarded a Nobel Prize in chemistry (false)<br><br>Irwin Rose was awarded a nobel prize in chemistry (true)<br>Irwin Rose was awarded a nobel prize in physics (false) |
| 14 | Bromelain is an enzyme mixture found in pineapples<br><br>Lysozyme is an enzyme found in saliva that plays a role in breaking down bacterial cell walls | Enzyme mixtures found in pineapples are classified as proteolytic enzymes<br><br>Enzymes found in saliva that break down bacterial cell walls are classified as antimicrobial enzymes | Bromelain is a proteolytic enzyme (true)<br>Bromelain is a antimicrobial enzyme (false)<br><br>Lysozyme is an antimicrobial enzyme (true)<br>Lysozyme is a proteolytic enzyme (false) |

| Pair | Stem 1 (AB) | Stem 2 (BC) | Novel integration fact (AC) |
|---|---|---|---|
| 15 | Angkor Wat in Cambodia is a massive temple complex built in the 12th century<br><br>The Terracotta Army consists of thousands of life-sized clay soldiers and horses | The massive temple complex in Cambodia was built by the Khmer Empire<br><br>Thousands of life-sized clay soldiers and horses were built to accompany the first emperor of China in the afterlife | The Angkor Wat was built by the Khmer Empire (true)<br>The Angkor Wat was built to accompany the first emperor of China in the afterlife (false)<br><br>The Terracotta Army was built to accompany the first emperor of China in the afterlife (true)<br>The Terracotta Army was built by the Khmer Empire (false) |
| 16 | Axolotls are aquatic salamanders with regenerative abilities<br><br>Geckos are reptiles known for their adhesive toe pads | Aquatic salamanders with regenerative abilities are called urodeles<br><br>Reptiles known for their adhesive toe pads are called squamates | Axolotls are urodeles (true)<br>Axolotls are squamates (false)<br><br>Geckos are squamates (true)<br>Geckos are urodeles (false) |
| 17 | Capybaras are large rodents native to South America<br><br>Lemurs are primates found in Madagascar | Large rodents native to South America are called hystricomorphs<br><br>Primates found in Madagascar are called strepsirrhines | Capybaras are hystricomorphs (true)<br>Capybaras are strepsirrhines (false)<br><br>Lemurs are strepsirrhines (true)<br>Lemurs are hystricomorphs (false) |
| 18 | Brigantines are ships classified as clippers<br><br>Windjammers is a different name for iron-hulled sailing ships | Clippers are sailing vessels designed primarily for speed<br><br>Iron-hulled sailing ships are primarily designed for carrying cargo | Brigantines are primarily designed for speed (true)<br>Brigantines are primarily designed for carrying cargo (false)<br><br>Windjammers are primarily designed for carrying cargo (true)<br>Windjammers ships are primarily designed for speed (false) |

| Pair | Stem 1 (AB) | Stem 2 (BC) | Novel integration fact (AC) |
|---|---|---|---|
| 19 | Malfurada is a garden plant that often escapes from cultivation<br><br>Stone bramble is a plant that is native to Sweden | Garden plants that escape from cultivation become invasive<br><br>Native plants are non-invasive | Malfurada is invasive (true)<br>Malfurada is non-invasive (false)<br><br>Stone bramble is non-invasive (true)<br>Stone bramble is invasive (false) |
| 20 | QR codes, or Quick Response codes, were invented by an engineer at Denso Wave<br><br>The computer “Deep Blue” was the first computer system to defeat a reigning world chess champion | The company Denso Wave is a subsidiary of Toyota<br><br>The first computer system to defeat a reigning world chess champion was developed at the company IBM | QR codes were invented at a subsidiary of Toyota (true)<br>QR codes were developed by the company IBM (false)<br><br>The computer “deep blue” was developed by the company IBM (true)<br>The computer “deep blue” was invented at a subsidiary of Toyota (false) |