Bilingualism: Language and Cognition

cambridge.org/bil

Thinking creatively in two languages: Effects of mental imagery vividness, foreign language proficiency and hand gestures on bilingual creativity

Gyulten Hyusein and Tilbe Göksun

Department of Psychology, Koç University, Istanbul, Türkiye

Research Article

Cite this article: Hyusein, G. and Göksun, T. (2025). Thinking creatively in two languages: Effects of mental imagery vividness, foreign language proficiency and hand gestures on bilingual creativity. *Bilingualism: Language and Cognition* 1–16. https://doi.org/10.1017/S1366728925100151

Received: 29 August 2024
Revised: 27 April 2025
Accepted: 14 May 2025

Keywords:
creativity; hand gestures; mental imagery vividness; foreign language effect

Corresponding author:
Gyulten Hyusein;
Email: ghyusein19@ku.edu.tr

This research article was awarded Open Data badge for transparent practices. See the Data Availability Statement for details.

Abstract

This study investigated the influence of language context on creative thinking, mental imagery vividness and the use of representational hand gestures among Turkish-English bilinguals. Participants solved verbal divergent and convergent thinking tasks in both their native (L1) and second languages (L2) and self-reported their mental imagery vividness during each task. Results revealed that participants were more creative and experienced more vivid mental imagery in L1 compared to L2. Surprisingly, L2 proficiency was not associated with L2 imagery. Gestures in L1 had a positive association, while gestures in L2 had a negative association with divergent thinking. Higher gesture rates were related to lower convergent thinking performance in both languages, especially when imagery vividness was high. These findings suggest that creativity and mental imagery vividness might depend on the language context. The role of gestures for verbal creativity might also differ according to the language used.

Highlights

- We examined language context (L1–L2) in creativity, imagery vividness, and gestures.
- Verbal creativity scores were higher in one's L1 compared to their L2.
- Vividness of mental imagery was higher during L1 rather than L2 creative thinking.
- Representational gestures had opposing effects on L1 versus L2 divergent thinking.
- Gestures were negatively related to convergent thinking when vividness was high.

1. Introduction

In today's highly globalized world, many professionals work in their second language (L2). As many fields rely on creative thinking skills and problem-solving (e.g., science, engineering, arts and humanities), the need to understand the potential effects of using a foreign language on creativity becomes highly relevant (Nothelfer & Nothelfer, 2020). This study investigates how creative thinking differs between one's second (L2) and first languages (L1). Although creativity is linked to the 'bilingual advantage' (Hommel et al., 2011; Lange et al., 2020; Rabia & Alattawna, 2022), little research examines creativity in a second language. Research also shows that lower L2 proficiency leads to reduced L2 imagery vividness (Blazhenkova et al., 2023; Hayakawa & Keysar, 2018). As imagery is important for creative thinking (e.g., Abraham, 2016; Friedlander et al., 2024; Le Boutillier & Marks, 2003), creativity in L2 might also be diminished compared to L1. If that is the case, another goal of the present study is to investigate whether hand gestures would benefit L2 creativity by activating and amplifying mental images as some of the gesture frameworks suggest (e.g., the Gesture-for-Conceptualization Hypothesis by Kita et al., 2017). We will examine whether these processes occur in the same manner for verbal divergent and verbal convergent thinking. *Divergent thinking* is measured by the ability to generate a great number of original, flexible and elaborate ideas. *Convergent thinking* is gauged by having an insight into a problem or finding the best possible solution (Guilford, 1950; Mednick, 1962).

1.1. Bilingualism and creativity

Research on how creativity is expressed in a second language is scant. The association between bilingualism and creativity is based on the hotly debated notion of enhanced executive functioning in bilinguals, manifested also in creative thinking (e.g., Kharkhurin, 2011, 2017; Lee & Kim, 2010). Another possible mechanism behind the creative thinking advantage of bilinguals is their enriched conceptual knowledge (Kharkhurin, 2017; Van Dijk et al., 2018), which leads bilinguals to discover different and complex affordances. For example, *drinking/having tea* might evoke different images in English and Turkish. While for an English person, the action of *drinking/having tea* would most probably evoke the image of a porcelain cup filled with tea, for a Turkish person, the elicited image would be of a little tulip-shaped glass. Then, the concepts would also differ in their affordances, such as holding the cup of tea from its handle with your thumb and index finger and holding the glass of tea with your whole hand. Thus, an English-Turkish bilingual would discover and invent different and more complex affordances.

Another case of enriched conceptual knowledge in bilinguals might stem from *cross-linguistic polysemy*. Polysemy is defined as the quality of a word to have multiple related meanings (Maciejewski et al., 2023). For example, the word *bank* in English can refer either to a financial institution/building or the land alongside a river. Moreover, the word *bank* in Turkish means "a bench," which makes it a cross-linguistic polysemy. It is derived from the Italian word *banca*, which also means "a bench." Such instances of cross-linguistic polysemy can activate different concepts and uses of objects in bilingual speakers and benefit their creative thinking. For example, higher polysemy in English was linked to more creative design ideas in English-speaking graduate students (Georgiev & Taura, 2014).

How enriched and interconnected the conceptual knowledge of a bilingual is might also depend on various internal and external factors, such as individuals' proficiency level in their second language (Hommel et al., 2011; Kharkhurin, 2007, 2008), multicultural experiences (Fürst & Grin, 2017; 2021) or code-switching practices (Kharkhurin & Wei, 2014). For example, Hommel et al. (2011) showed a high-proficient bilingual advantage for convergent thinking but a low-proficient bilingual advantage for fluency in divergent thinking. However, a closer examination of the study reveals that the groups were only tested in their L1, which differed across groups (Dutch and German). Therefore, the results could be contaminated by the different stimuli used in each language.

To reach more generalizable conclusions, creativity also needs to be tested in L2. For example, Vaid et al. (2015) tested English-Spanish bilinguals on convergent thinking in both languages. According to participants' self-reports, their language proficiency was high and equal in both languages. Results showed that prior informal translational experience (language brokering) had a facilitative effect on convergent thinking performance, particularly for Spanish. However, whether Spanish was L1 or L2, and whether the exposure order influenced results, remains unclear. The authors reported that brokers' (those who had prior translational experience) Spanish proficiency was higher than that of non-brokers', which might have affected the results.

Recently, computational network analyses were used to study the relationship between bilingualism and creativity (e.g., Fernández-Fontecha & Kenett, 2022; Lange et al., 2020). Lange et al. (2020), who used semantic networks and Bayesian analysis, did not find an association between bilingualism and creativity or semantic network and creativity. They tested L1-English L2-Spanish bilinguals, L1-Spanish L2-English bilinguals and English monolinguals on verbal divergent thinking in English. One drawback of the study was that bilingualism was treated as a categorical variable based on a cut-off proficiency score on the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian et al., 2007). Another limitation is that they only measured creativity and semantic networks in English but not in Spanish, even though Spanish was the native language of a great proportion of the participants. Semantic networks were measured by a semantic fluency task also conducted in English only. Unlike Lange et al. (2020), Fernández-Fontecha & Kenett (2022) found an association between bilingual adolescents' semantic memory structure and their creativity performance using semantic network analyses. They divided adolescents into two groups of low and high creativity according to their verbal and figural creativity scores obtained from the PIC-J creativity battery (Artola et al., 2008), which is based on the Torrance Test of Creative Thinking (Torrance, 1990) and Guilford's Alternate Uses Test (Guilford, 1967). Different from low creative individuals, highly creative individuals' L1 semantic memory structure was similar to their L2 memory structure. Moreover, highly creative individuals were more fluent in both languages compared to less creative individuals.

The relationship between bilingualism and creativity is rather complex, and the findings on this link are mixed. Aiming for a single correct answer or expecting one study to correct all the flaws would be quite a reductionistic approach. Researchers use different definitions and measurements of creativity and bilingualism, treat them as categorical variables using cut-off points or do not control for the language of testing (L1, L2, L3, etc.). We should rather aim for a multifactor approach to bilingual experiences that considers the missing 'slices of Swiss cheese' in the bilingual package (Bialystok, 2021). What has been less studied and might serve as an important missing piece in the package is whether creativity is expressed differently in L1 and L2. The phenomenon called "the foreign language effect" might help us understand those differences.

1.2. The foreign language effect and creativity

The *foreign language effect* is used to suggest that thinking in a foreign language reduces decision biases as it leads to a greater emotional distance than speaking or thinking in a native language (e.g., Caldwell-Harris, 2014; Dylman & Bjärtå, 2018; Harris et al., 2003; Pavlenko, 2005). Earlier work demonstrated potential foreign language effects on decision-making (e.g., Costa et al., 2014; Keysar et al., 2012) and moral dilemmas (Corey et al., 2017; Hayakawa et al., 2017). The mechanisms behind the foreign language effect remain debated. As decisions in L2 have been identified as more logical, less emotional and more utilitarian, some researchers explain it as a shift from the intuitive Path 1 to the more deliberate Path 2 (Caldwell-Harris & Ayçiçeği-Dinn, 2009; Dewaele, 2010; Pavlenko, 2005). This suggests that Path 1 is more emotional, and Path 2 is more rational. Emotions were also linked to creative performance. For example, De Dreu et al. (2008) showed that creativity, measured by fluency and originality in verbally generating creative ideas, can be enhanced both by experiencing positive (happy, elated) and negative (angry, fearful) emotions. If thinking in L1 is more intuitive and emotional, then increased L1 creative performance would be expected.

Higher creativity in L2 can also be anticipated. Research shows that moving individuals away from traditional or established ways of thinking, as thinking in L1 is, increases their creative ideas (e.g., Gocłowska et al., 2012; Sassenberg & Moskowitz, 2005). Indeed, Stephan (2017) showed that participants were more creative in designing t-shirt outlines and drawing an alien character for a story when they were in a foreign language context than in their native language context. However, a recent large-scale (430 participants) international experiment with participants from France, Germany and the U.S. did not find a general foreign language effect on creativity (Nothelfer & Nothelfer, 2020). The task in this study was also nonverbal. In particular, the participants had to design a real-effort creative product, which was later evaluated with the consensual assessment technique (CAT; Amabile, 1982). In this technique, each product was rated by six raters on a 9-point creativity scale, quality of the technical execution and aesthetic appeal. The foreign language effect on creativity might also depend on how vivid mental imagery is in L1 compared to L2.

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

1.3. Mental imagery and creativity

Theoretical frameworks such as the creative cognition approach (The Geneplore Model, Finke et al., 1992; Smith et al., 1995) have emphasized the role of nonverbal representations, such as mental imagery, in the creative process. According to this model, two basic processes are involved in creative imagery. *Generative processes* are used in the construction of pre-inventive structures (e.g., memory retrieval and association, mental synthesis and mental transformation). *Exploratory processes* are used to examine and interpret the pre-inventive structures (e.g., conceptual interpretation, functional inference and hypothesis testing). There is a cycle of *generative* and *exploratory* processes until the final form is achieved. This approach is mostly valid for visual creativity as it emphasizes the role of image generation in creating structures and objects. For example, when people are engaged in creative problem-solving or imagination, they might close their eyes or look away to an empty part of the environment to engage with their internal cognitive world (Salvi & Bowden, 2016).

Mental imagery vividness, more specifically, refers to the clarity and detail of evoked images. This ability is considered a crucial source of creative inspiration (Abraham, 2016; Friedlander et al., 2024). Earlier findings showed a consistent association between self-reported imagery vividness and divergent thinking performance (Le Boutillier & Marks, 2003). People with *hyperphantasia* (extremely vivid, "photographic" imagery) often pursue creative professions, while those with *aphantasia* (absence of mental imagery) are more represented in fields like computing or mathematics (Zeman et al., 2020). Hyperphantasia is also linked to *synesthesia* (cross-sensory experiences), which itself is associated with higher creativity, openness to experience and vivid imagery (Chun & Hupe, 2015).

1.4. Mental imagery in a second language

The importance of imagery in language, in general, is highlighted mainly by the Dual Coding Theory (DCT; Paivio, 1969), which suggests that two modality-specific systems get activated for all types of cognition. These two systems are a nonverbal system comprising *imagens* (sensorimotor imagery) and a verbal one comprising *logogens* (linguistic symbols). The two systems are independent but interconnected and can be used separately or together, depending on the task at hand. Bilingual individuals have separate *logogen* systems for their different languages. However, those systems are also interconnected not only directly but also through a common *imagen* system (Jared et al., 2012). If L2 is acquired later in life, imagery in L2 might be weaker because of weaker connections between L2 *logogens* and the shared *imagens.*

A recent upsurge in research on imagery provided evidence for weaker imagery in L2 (Blazhenkova et al., 2023; Dorfman et al., 2025; Hayakawa & Keysar, 2018; Jansson & Dylman, 2021; Montero-Melis et al., 2020; Oshima & Morishima, 2023). Two of these studies found that imagery was less vivid in L2 compared to L1 across its different modalities, such as visual (object and spatial) and auditory, and the proficiency level of individuals might explain this effect (Blazhenkova et al., 2023; Hayakawa & Keysar, 2018). Montero-Melis et al. (2020) critiqued Hayakawa and Keysar (2018), pointing out their methodological weaknesses, such as subjective imagery measures and inadequate comprehension control measures. Nevertheless, Blazhenkova et al. (2023) ruled out some of those flaws by emphasizing evidence showing that subjective imagery reports correlate with performance tests when the tests measure the corresponding type of imagery, like object versus spatial imagery (e.g., for a review, see McAvinue & Robertson, 2007).

Reduced mental imagery in L2 might be one of the mechanisms behind the foreign language effect. For example, reduced mental imagery in L2 has accounted for the foreign language effects previously observed in moral dilemmas (Dorfman et al., 2025; Hayakawa & Keysar, 2018; Oshima & Morishima, 2023). Another study indicated that instructing participants to use their mental imagery while solving moral dilemmas increased deontological (emotional) choices (Oshima & Morishima, 2023). More recently, Dorfman et al. (2025) proposed an empirico-theoretical framework highlighting the impact of L2 proficiency on mental imagery vividness during reading moral dilemmas. The framework was also based on a finding by Birba et al. (2020) suggesting that greater L2 proficiency leads to a stronger coupling of motor brain networks during L2 reading. This implies more consolidated embodied simulations in L2 that are similar to L1 text processing. Krasny and Sadoski (2008) found that as bilinguals progress in their ability to read in their L2, ratings of imagery and affective responses become closer to those reported to reading the same text in L1. This highlights the role of language proficiency in imagery and affect (see also Jansson and Dylman, 2021) for differentiation of emotionality and vividness in L1 and L2 autobiographical memories).

Imagery in L2 can be weaker because of weaker connections between L2 *logogens* and the shared *imagens* as proposed in the Dual Coding Theory. Can gestures, which are known to activate and maintain visuospatial imagery (Hostetter & Alibali, 2008; Kamermans et al., 2019; Wesp et al., 2001), act as reinforcers of the connection between L2 verbal representations and imagery?

1.5. Can gestures compensate for low imagery in L2 and enhance creative thinking?

The format of mental imagery has long been a topic of debate, with some camps arguing that mental images are picture-like representations (Kosslyn, 1982, 1994; Kosslyn et al., 2006), while others support a descriptive approach, where mental images rely on an abstract, language-like format (Pylyshyn, 1979, 1981, 2002). Over the years, a new approach, *embodied cognition*, emerged, where the interdependence of perception, action and cognition is emphasized (Palmiero et al., 2019). Therefore, *hand gestures*, as part of the embodiment of thought and imagery, might also be essential for the formation and vividness of mental imagery.

Co-speech hand gestures are produced spontaneously when we speak and are closely synchronized with speech content (Bergmann et al., 2011; McNeill, 1992). *Iconic* (e.g., making a circular movement with the index finger or the whole hand to represent the wheel of a car) and *metaphoric* gestures (e.g., making an upward movement with the hand to represent promotion or increase in prices), are often classified as *representational* gestures (Kita et al., 2017; Krauss, 1998) and will be the focus of the current article.

As gestures activate mental images, they should be beneficial for visual/figural creativity irrespective of the language. Prior research suggests that gestures support spatial reasoning and word retrieval (Atit et al., 2015; So et al., 2012), which may explain why bilinguals gesture more in both languages compared to monolinguals (Nicoladis, 2007). As verbal skills in L2 are expected to be lower compared to L1, we would also expect people to use gestures to aid verbal creativity in L2. However, individual cognitive differences should be considered when hypothesizing that gestures would boost creativity through amplifying imagery vividness. Comprehending and producing gestures depend on one's spatial skills, and

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

young adults may use *gesture-as-a-compensation-tool* not only for lower verbal but also for lower spatial skills (for a review, see Özer & Göksun, 2020).

Since we execute gestures in the immediate space around us, being aware of how to use that space successfully helps us produce the right gestures to benefit both verbal and nonverbal problem-solving tasks. To support that, Hyusein and Göksun (2023) showed that high mental imagery skills (i.e., the ability to generate, maintain, and manipulate images in the eye's mind) were required for gestures to aid verbal convergent creative thinking in one's native language. That study did not measure whether vividness of imagery played a role in that relationship. Regarding verbal divergent thinking, both studies with children and adults in L1 showed that encouraging people to use gestures also increased the number and the quality of creative ideas (Hyusein & Göksun, 2024b; Kirk & Lewis, 2017). Mental imagery skills did not affect that relationship, at least in adults (Hyusein & Göksun, 2024b), however, vividness has not been tested.

For gestures to enhance vividness in L2 and consequentially L2 creativity, L2 proficiency might play an important role. For example, Zvaigzne et al. (2019) found an interesting relationship between children's L2 proficiency and iconic gesture use. Children with intermediate L2 proficiency gestured less compared to those with high and low proficiency on a cartoon description task in L2. The gestures of the low-proficiency group, whose descriptions were also less precise compared to the other children, used their gestures either to facilitate lexical access or to supplement their verbal message. The authors also commented that the high-proficiency group might have found the description task easy, which freed their cognitive resources for the execution of gestures. The proficiency level of the intermediate group was just enough for producing as accurate cartoon descriptions as the high-proficiency group but had no resources left to gesture. A recent study with young adults (Arslan et al., 2024) corroborated this finding, showing that higher L2 proficiency was also associated with a higher representational gesture rate but also a higher disfluency rate in L2. This was against the hypothesis that gestures compensate for weak language skills, but gestures might be signals of disfluent speech that needs correction, especially for those who have high L2 proficiency. Young adults used more representational gestures in their L2 (however, proficiency was not controlled for) to express emotional information, which also intensified subsequent emotional ratings (Özder et al., 2023). As we have already emphasized the link between imagery vividness and emotionality in L2, the study of Özder et al. (2023) provides further evidence that representational gestures might enhance L2 creativity through the activation of emotions.

1.6. The present study

The present study aims to investigate if creativity (verbal convergent and divergent thinking) is expressed differently in L1 (Turkish) and L2 (English). We expect L1 creativity to be higher due to higher verbal skills in L1 in general. As imagery plays an important role in creative thinking, we will also examine the role of the vividness of imagery in creative performance in L1 and L2. Decreased vividness of imagery in L2 is also explained by decreased proficiency (e.g., Blazhenkova et al., 2023). We expect higher imagery vividness in L1 to be another reason for higher L1 creativity. Additionally, we will examine the role of hand gestures in creative thinking in L1 and L2. As hand gestures activate and maintain visuospatial imagery and intensify emotions, we expect spontaneous representational gestures in L2 to strengthen the verbal-imagery representations route (based on the Dual Coding Theory). This will also help activate creative imagery and verbal creativity in L2.

In sum, we expect higher L2 proficiency along with a higher representational gesture use rate to lead to higher vividness of imagery in L2 creativity, which might positively affect L2 creativity. Even though speaking and learning a second language can enhance divergent thinking (Ghonsooly & Showqi, 2012), previous studies generally assessed creativity in a participant's first language. Providing evidence of whether the favorable effects of bilingualism on creativity are transmitted to L2 as well could be a valuable reference point for bilingual people when they engage in creative problem-solving. This study is also unique because it will investigate some overlooked factors that might affect bilingual creativity, namely vividness of mental imagery and hand gestures. Both are important for the bilingual creativity literature because they can provide information on ways to stimulate creativity in L2, such as by encouraging the use of hand gestures, which can promote vivid imagery and lead to enhanced creative output.

2. Method

2.1. Participants

By using the G*power software (Faul et al., 2009) for repeated measures within factors analysis of variance (ANOVA), and by setting the alpha level as 0.05, the effect size as (np2) 0.25 and the power as 0.80, we determined that we need a sample of 34 participants. A total of 40 Turkish-English bilingual (L1-Turkish, L2-English) speakers (20 females) participated in the study. They completed both language conditions one week apart, with a counterbalanced order. Four participants did not attend the second session. Therefore, there were 36 participants (18 females) who attended both sessions (Turkish and English). Participants were undergraduate and graduate students from Koç University between the ages of 18 and 28 ($M_{age} = 21.8$, $SD = 2.43$). Participants received either course credit or monetary compensation. The study was approved by Koç University's Institutional Review Board committee with the approval number 2023.022.IRB3.006. We obtained participants' informed consent before the study.

Participants' age of starting to learn L2-English ranged from 1 to 18 years ($M_{age} = 9.30$, $SD = 3.55$). All participants indicated that they had an L2 experience in a family, a country, or a school environment where English was frequently spoken. Their English proficiency (a cumulative score for understanding, speaking and reading) averaged 22 out of 30 ($Mscore = 21.9$, $SD = 3.56$), which indicated high English proficiency.

2.2. Materials

2.2.1. Alternative Uses Task (AUT)

This is a test of verbal divergent thinking where participants were instructed to come up with as many possible creative uses of an everyday object as they could in 3 minutes. They were also explicitly encouraged to be creative and told by the experimenter that the more creative the uses are, the better it would be. We used four objects (newspaper, pencil, shoe, towel) in total – two for each condition, in a counterbalanced order. Scoring was based on four components:

2.2.2. Fluency

The total number of ideas/responses given by the participant. Each response received 1 point.

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

2.2.3. Originality

Each response was compared to the total number of all participant responses. Responses that were given by 5% of the group were counted as unusual (1 point), and responses given by 1% of them were counted as unique (2 points).

2.2.4. Flexibility

Flexibility was measured by the number of different categories the participant's responses belonged to. Each unique category received 1 point. If a response belonged to a category that was previously assigned to another response for that specific object, it would receive a score of 0.

2.2.5. Elaboration

Elaboration was measured by the amount of details in the responses, e.g., "a boat" received 0 points, whereas "as a boat, by putting toys in it, in a pool" received 2 points (1 point for an explanation of 'putting toys in it' and another one for further detail about 'in a pool').

Two trained assistants transcribed and coded the AUT responses. Interrater reliability was calculated for fluency, flexibility and elaboration for 20% of the data. Interrater intra-class correlation coefficients (ICC) indicated almost perfect agreement for all three measures, $ICC_{fluency} = .999$, 95% CI [.998, 1.000], $p < .001$; $ICC_{flexibility} = .926$, 95% CI [.854, .963], $p < .001$; $ICC_{elaboration} = .888$, 95% CI [.785, .944], $p < .001$. As the originality score was calculated according to a standardized procedure, there was no need to assess interrater reliability for it.

2.2.6. Remote Associates Test (RAT)

This is a measure of verbal convergent thinking. In this task, participants are presented with three unrelated words (e.g., cottage, Swiss, cake) and are asked to come up with a fourth word that is a common associate of those three words (cheese). We used 10 triads in each condition. The words were presented on a white screen and were read out loud by the experimenter. Participants had 30 seconds per triad to come up with a relevant answer. Scoring was based on the number of correct responses with each correct response scored as 1. Participants could get a maximum total score of 10. The stimuli for the Turkish condition were based on Hyusein and Göksun (2023). The stimuli of the English version were selected based on solution rates from Sio et al. (2021) so that triads in both conditions would be of comparable difficulty.

2.2.7. Vividness of Mental Imagery

Vividness of mental imagery during verbal divergent and convergent thinking was measured with the question, "While doing this task, you may have had some imagery experiences evoked. Please rate by advancing the line in the scale below, the clarity and distinctness with which you were able to generate images while solving this task" on a scale of 0–100 after each trial of the AUT and the RAT. The question was adapted from the *Read & Imagine Task* developed by Blazhenkova et al. (2023). Separate vividness of imagery scores were calculated for AUT and RAT by estimating the average of vividness scores for all trials during the respective task.

2.2.8. *The Language Experience and Proficiency Questionnaire (LEAP-Q)*

LEAP-Q is one of the most widely used language history questionnaires that assesses L2 speaking, reading and writing proficiency, age of acquisition/starting age of learning a language, percentage of L2 usage and exposure in daily life. We decided to use the LEAP-Q as self-reported proficiency was found to be highly correlated with general language performance (e.g., Estremera & Torres, 2014; Marian & Fausey, 2006).

2.3. *Procedure*

Participants signed up for the first in-person testing sessions through the university's subject pool. They were randomly assigned either to a Turkish or an English first session. Their second testing session was scheduled for one week later and was conducted in the other language (e.g., if their first session was in Turkish, the second one was in English, and vice versa). Both sessions took place in a laboratory room where the experimenter (either the first author or a trained assistant) was present with the participant throughout the testing.

On the first day, participants completed the consent form in Turkish, the AUT and the RAT in a counterbalanced order either in Turkish or English and the LEAP-Q in Turkish. On their second day, they completed the AUT and the RAT in the other language and the MIT in Turkish. After each AUT or RAT trial, they also answered the vividness of mental imagery questions in the respective language. All trials and instructions of the AUT, the RAT and the MIT were presented on a computer screen and read out loud by the experimenter. The consent form, the vividness questions and the LEAP-Q were filled in by the participant through Qualtrics. Answers to the AUT and the RAT were given orally and were video recorded for gesture and creativity coding. At the end of the second session, participants were debriefed, awarded course credits or cash compensation and thanked for their participation.

2.4. *Gesture coding*

Speech and gestures for the AUT were transcribed and coded in Microsoft Excel by two trained research assistants. The first author checked the gesture coding and resolved any ambiguities pointed out by the assistant. McNeill-type co-speech gestures, i.e., iconic, deictic, metaphoric and beat gestures, were coded (McNeill, 1992). Palm-revealing and emblem gestures were coded in an 'other gestures' category. All gesture types were mutually exclusive from each other. Iconic and metaphoric gestures were combined in a new category called *representational gestures.* Interrater reliability was calculated for 20% of the data, which was coded by both assistants. There was a substantial agreement for identifying gesture types ($\kappa = .732$, $p < .001$) and excellent agreement for categorizing gesture frequency across trials (ICC = .964, 95% CI [.949, .982], $p < .001$) between the two coders. Gesture frequency rate was calculated for each gesture type by dividing the number of gestures produced by the number of words spoken in each trial. We used gesture frequency rate and not the sheer number of gestures produced because as speech increases, so does the number of gestures produced. Calculating a gesture rate is beneficial for controlling individual differences in speech production (So et al., 2009). To test our hypotheses, we only included *representational gesture* frequency in the analyses.

All data are available on the Open Science Framework: https://osf.io/4paf2/?view_only=9ad2d853d04946da943bcfd19af1a2c1

3. Results

Descriptive statistics (i.e., mean, standard deviation, minimum and maximum) of the AUT, RAT, vividness of mental imagery and

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

Table 1. Mean (M), standard deviation (SD), minimum (Min.), and maximum (Max.) values of the Alternative Uses Task (AUT), Remote Associates Test (RAT), vividness of mental imagery ratings during AUT and RAT, and representational gesture frequency rates during AUT and RAT across conditions (Turkish and English)

	Conditions							
	Turkish (L1)				English (L2)			
	M	SD	Min.	Max.	M	SD	Min.	Max.
AUT score	71.7	27.2	24	127	57.3	24.6	19	103
RAT score	6.4	1.7	2	10	1.5	1.5	0	5
AUT vividness	70.9	20.1	31	100	61.3	23.8	10	100
RAT vividness	55.0	20.1	12.6	94.5	31.6	16.3	0.9	76.0
AUT representational gesture frequency	0.08	0.04	0.01	0.17	0.08	0.04	0.01	0.18
RAT representational gesture frequency	0	0.01	0	0.02	0.01	0.02	0	0.09

representational gesture frequency rates during the Turkish and English conditions are shown in Table 1.

Statistical analyses (repeated measure analysis of covariances [AN(C)OVAs]) were carried out with the *aov()* and *lm()* functions in R (R Core Team, 2013). The *summary()* and *eta_squared()* functions were used to obtain *F*-statistics, *p*-values, and effect size. The *ggplot()* function was used to visualize the results. For our post-hoc analysis, we used the *cor.test()* function for bivariate correlations and the *emmeans()* and *contrast()* functions for pairwise comparisons. All continuous variables were normalized with the *scale()* function before running the repeated measure analyses.

3.1. Vividness of mental imagery and creativity in L1 and L2

Repeated measure ANOVAs revealed a main effect of condition on both divergent, $F(1,35) = 15.01$, $p < .001$, $\eta 2 = .07$, and convergent thinking, $F(1,35) = 220.9$, $p < .001$, $\eta 2 = .64$. Post-hoc pairwise comparisons using the Bonferroni correction indicated that AUT scores in the Turkish condition ($M = 71.7$, $SE = 27.2$) were significantly higher than those in the English condition ($M = 57.3$, $SE = 24.6$), $t\,(35) = -3.87$, $p < .001$; and RAT scores were similarly significant – respectively for Turkish ($M = 6.4$, $SE = 1.7$), and English ($M =1.5$, $SE = 1.5$), $t\,(35) = -14.86$, $p < .001$. There was also a main effect of language on vividness of mental imagery for both during divergent, $F(1,35) = 7.08$, $p = .01$, $\eta 2 = .17$, and convergent thinking, $F(1,35) = 46.67$, $p < .001$, $\eta 2 = .57$. Post-hoc pairwise comparisons indicated that vividness of mental imagery during divergent thinking in the Turkish condition ($M = 70.9$, $SE = 20.1$) was significantly higher than in the English condition ($M = 61.3$, $SE = 23.8$), $t\,(35) = -2.66$, $p = .01$. Vividness of mental imagery during convergent thinking in the Turkish condition ($M = 55.0$, $SE = 20.1$) was also significantly higher than in the English condition ($M = 31.6$, $SE = 16.3$), $t(35) = -6.83$, $p < .001$.

Pearson's correlational analysis indicated that L2 proficiency was only positively and moderately correlated with AUT and RAT scores in English, $r(36) = 0.329$, $p = .04$, and $r(36) = 0.358$, $p = .03$, respectively, but not with the vividness of mental imagery in English.

3.2. Effects of vividness of mental imagery and L2 proficiency on L1 and L2 creativity

To investigate the effects of imagery vividness and L2 proficiency on creative thinking in L1 and L2, we carried out repeated measure ANCOVAs by adding mental imagery vividness scores during divergent (AUT) and convergent (RAT) thinking and L2 proficiency as covariates.

Results for divergent thinking indicated that there were main effects of language, $F(1,30) = 20.7$, $p < .001$, $\eta 2 = .41$, vividness of imagery, $F(1,30) = 11.8$, $p = .002$, $\eta 2 = .28$ and L2 English proficiency, $F(1,32) = 6.8$, $p = .01$, $\eta 2 = .18$. There were no significant two- or three-way interactions, *ps* > .05. Post-hoc pairwise comparisons using the Bonferroni correction indicated that AUT scores in the Turkish condition ($M = 71.7$, $SE = 27.2$) were still significantly higher than those in the English condition ($M = 57.3$, $SE = 24.6$), $t\,(30) = -2.96$ $p = .006$. Pearson correlation analysis revealed a statistically significant strong positive correlation between divergent thinking scores and vividness of mental imagery for both languages combined, $r(74) = 0.655$, $p < .001$, and a statistically significant weak positive correlation between divergent thinking scores and L2 English proficiency for both languages combined, $r(74) = 0.273$, $p = .02$.

Results for convergent thinking indicated that only the main effect of language was significant, $F(1,30) = 209.3$, $p < .001$, $\eta 2 = .64$. There were no effects of vividness of mental imagery or L2 proficiency, and no interactions, *ps* > .05. Post-hoc pairwise comparisons using the Bonferroni correction indicated that RAT scores in the Turkish condition ($M = 71.7$, $SE = 27.2$) were still significantly higher than those in the English condition ($M = 57.3$, $SE = 24.6$), $t\,(30) = -7.75$ $p < .001$, even when controlling for effects of imagery vividness and L2 proficiency.

These results indicated that both divergent and convergent thinking scores and vividness of mental imagery were higher in L1 Turkish compared to L2 English. L2 proficiency and task-specific vividness of mental imagery (i.e., during divergent or convergent thinking) were positively associated with divergent, but not convergent thinking, in both L1 and L2 (see Figures 1 and 2).

3.3. Effects of representational gestures, vividness of imagery and L2 proficiency on L1 and L2 creativity

We investigated the effects of representational gesture use in addition to imagery vividness and L2 proficiency on L1 and L2 divergent and convergent thinking.

First, we conducted paired-sample t-tests to see whether there were differences in representational gesture use between divergent and convergent thinking tasks in each language. There were no differences in gesture rates during the AUT and the RAT in the L1 Turkish, $t(37) = 1.75$, $p = .09$, and in the L2 English conditions, $t(37) = -1.05$, $p = .30$. Therefore, overall representational gesture rates between the two tasks in each language did not differ.

Next, we tested whether representational gesture use for each task differed between the two languages. Repeated measures ANOVA indicated a main effect of language on representational

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

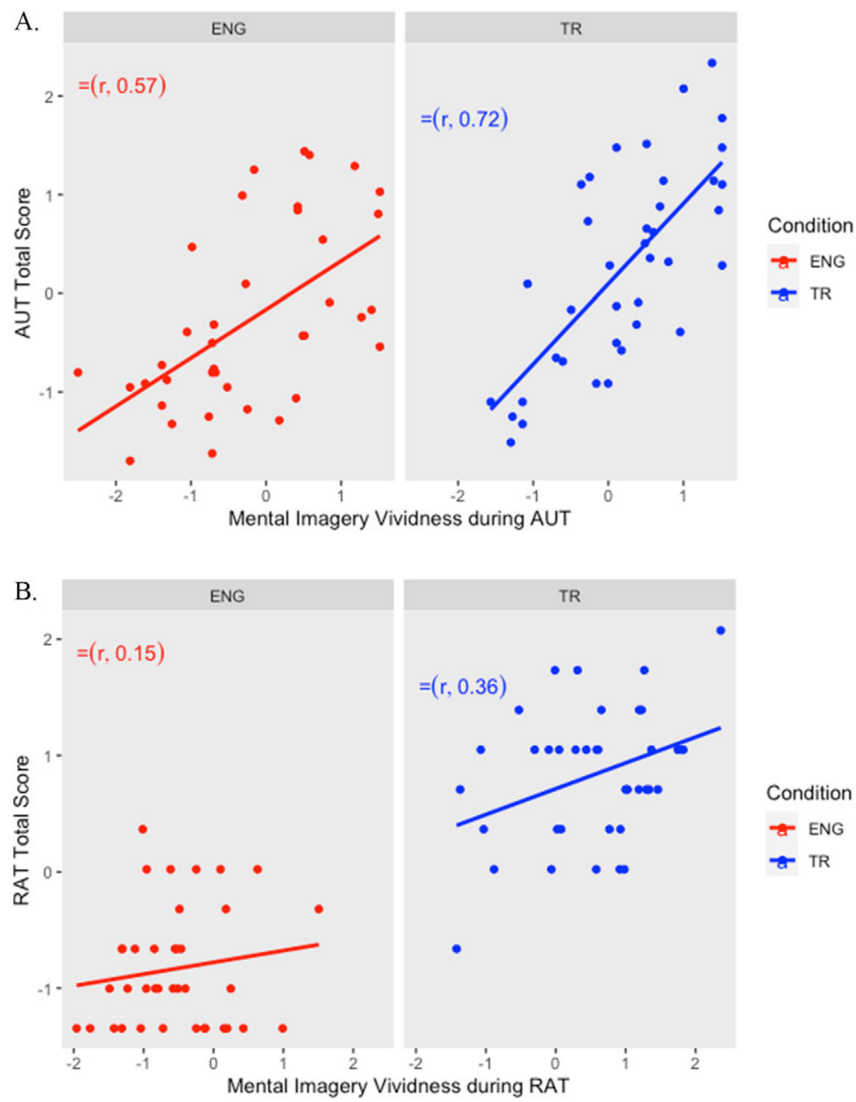

Figure 1. (A) Relationship between Mental Imagery Vividness ratings during the Alternative Uses Task (AUT) and AUT Total Scores in English (ENG) and Turkish (TR). (B) Relationship between Mental Imagery Vividness ratings during the Remote Associates Test (RAT) and RAT Total Scores in English (ENG) and Turkish (TR).

gesture use during convergent thinking, $F(1,35) = 9.6$, $p = .004$, $\eta 2 = .21$. Post-hoc comparisons using Tukey's honestly significant difference (HSD) test with adjusted p-values showed that participants gestured significantly more during the L2 English session compared to the L1 Turkish session ($M_{difference} = 0.510$, $SE = 0.147$, $t(35) = 3.471$, 95% CI [0.218, 0.802], $p < .001$). We did not find an effect of language on representational gestures during divergent thinking $F(1,35) = 0.001$, $p = .981$, $\eta 2 = .00$, (see Figure 3).

Then, we carried out repeated measures ANCOVA to test whether L2 proficiency, vividness of imagery and representational gesture use during convergent thinking affected RAT scores over and above language condition (L1 versus L2). There was a significant three-way interaction among representational gestures, vividness of mental imagery and L2 proficiency, $F(1,22) = 4.6$, $p = .04$, $\eta 2 = .17$. As all three predictor variables were continuous, we used linear regression to explore the nature of the relationship and compute simple slopes. There was a significant two-way interaction between representational gesture frequency and imagery vividness $b = -0.28$, $SE = 0.13$, $t(68) = -2.197$, $p = 0.03$, indicating that the relationship between gesture frequency and RAT scores depended on the level of imagery vividness (see Table 2). Simple slope analysis revealed that the slopes of representational gestures for mean and high (+1SD) imagery vividness were significant, $b = -0.35$, $SE = 0.10$, $t(68) = -3.53$, $p = .001$ and $b = -0.63$, $SE = 0.19$, $t(68) = -3.28$, $p = .002$, respectively (see Figure 4). Thus, the relationship between representational gestures during convergent thinking and RAT scores becomes more negative as imagery vividness during convergent thinking increases.

We also conducted repeated measures ANCOVA for divergent thinking to test whether representational gesture use during divergent thinking affected AUT scores over and above language condition (L1 versus L2), L2 proficiency, and vividness of imagery during divergent thinking. We found a significant two-way interaction between language condition and representational gestures, $F(1,22) = 4.97$, $p = .04$, $\eta 2 = .18$ (see Figure 5). The main effect of imagery vividness also persisted, $F(1,22) = 13.55$, $p = .001$, $\eta 2 = .38$. Post-hoc simple slopes analysis indicated that neither the slope for the English language condition ($b = -0.11$, $SE = 0.15$, $t(90) = -0.71$, $p = 0.48$) nor the slope for the Turkish condition ($b = 0.06$, $SE = 0.17$, $t(90) = 0.38$, $p = 0.71$) was significant. This suggests that the frequency of representational gestures does not significantly predict divergent thinking scores either in L1 or in L2. However,

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

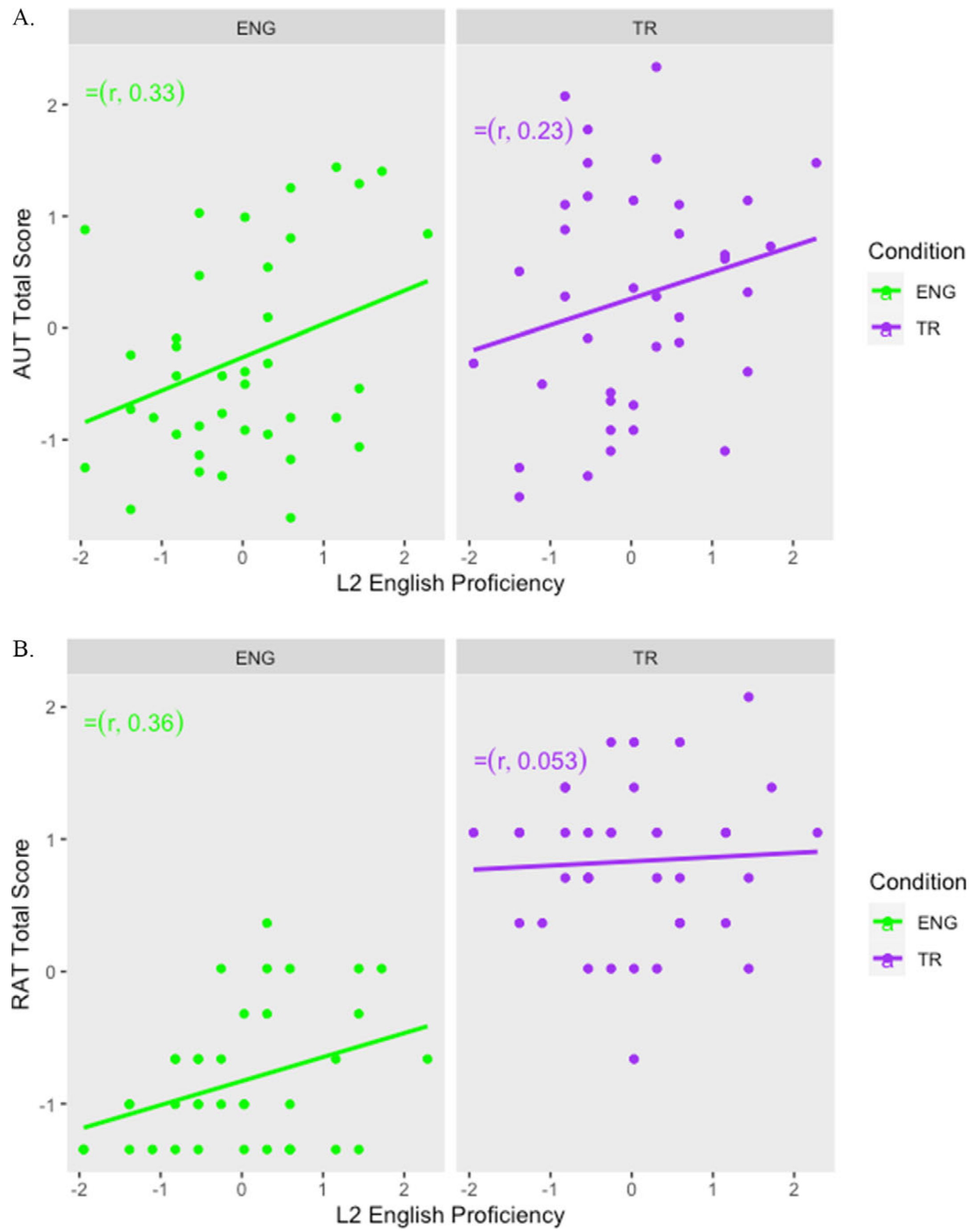

Figure 2. (A) Relationship between L2 English Proficiency and Alternative Uses Task (AUT) Total Scores in English (ENG) and Turkish (TR). (B) Relationship between L2 English Proficiency and Remote Associates Test (RAT) Total Scores in English (ENG) and Turkish (TR).

the significant interaction effect observed in the ANCOVA suggests that the relationship between representational gestures and divergent thinking may differ between the languages, though the effect is not strong enough to be significant within each language condition individually.

4. Discussion

The present study investigated whether creative thinking and vividness of mental imagery differed in one's native language (L1) versus second language (L2). We tested the hypothesis that a higher rate of representational gestures and higher proficiency in L2 were associated with higher mental imagery vividness. We expected representational gestures, L2 proficiency and mental imagery vividness to contribute to L2 creativity. Creativity was measured by verbal divergent and convergent thinking tasks. This study is novel in differentiating L1 and L2 creative thinking and examining the role of imagery vividness and gestures across both languages.

People were more creative and experienced more vivid mental imagery in L1 than L2. The hypothesis that higher L2 proficiency, along with a higher representational gesture use, would lead to higher L2 vividness of imagery and L2 creativity was not supported. Higher representational gesture use in L2 was negatively associated with L2 divergent thinking. We found a similar pattern for

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

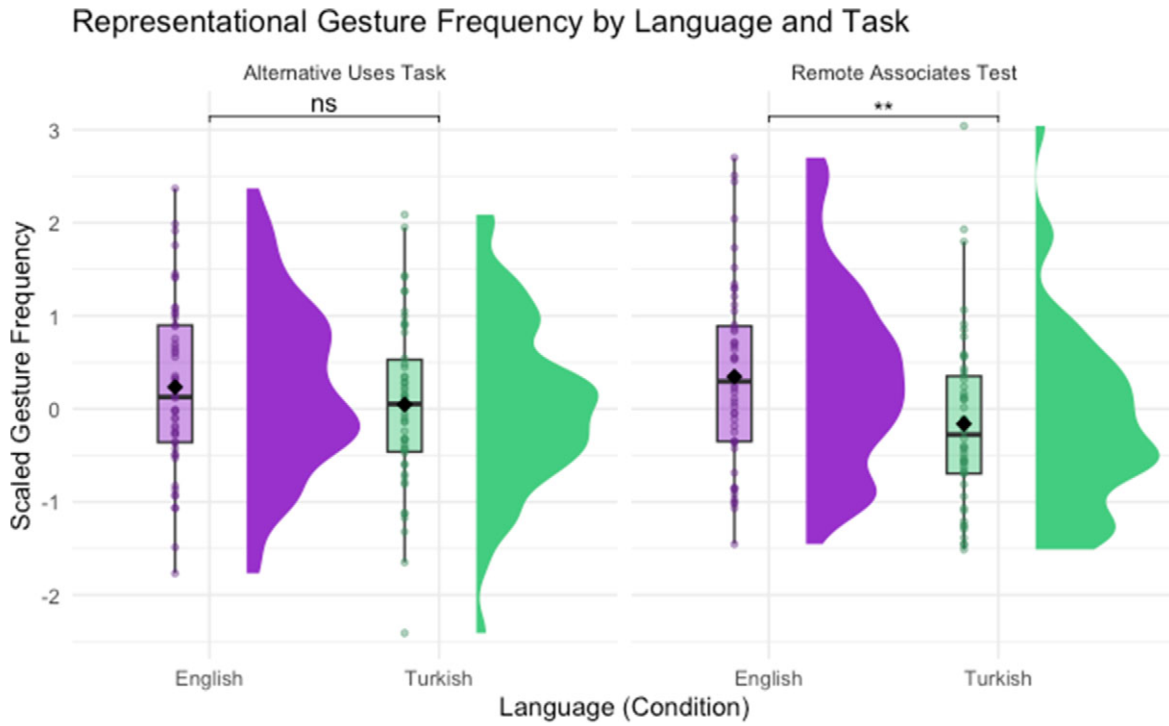

Figure 3. Raincloud plots of scaled representational gesture frequency during the Alternative Uses Task and the Remote Associates Test by language condition (L1: Turkish, L2: English). Each plot displays the distribution density, individual data points, and box plots. Black diamonds represent group means. Asterisks indicate statistically significant differences between conditions.

Table 2. Regression coefficients for a post-hoc regression model testing the effects of representational gestures and imagery vividness during convergent thinking and L2 proficiency on convergent thinking scores

Predictor	B	SE	t	p
Intercept	−0.022	0.089	−0.242	0.809
RAT representational gesture frequency (scaled)	−0.355	0.100	−3.539	< .001***
RAT vividness (scaled)	0.515	0.093	5.532	< .001***
English proficiency (scaled)	0.103	0.090	1.145	0.256
RAT gesture frequency × RAT vividness	−0.276	0.125	−2.197	0.031*
RAT gesture frequency × English proficiency	0.090	0.110	0.817	0.417
RAT vividness × English proficiency	−0.144	0.091	−1.575	0.12
RAT gesture frequency × RAT vividness × English proficiency	0.067	0.131	0.509	0.612

*$p < .05$, **$p < .01$, ***$p < .001$

convergent thinking irrespective of the language (L1 or L2), i.e., higher representational gesture use was related to lower convergent thinking, particularly when imagery was more vivid. Finally, L2 proficiency did not affect these interactions (see Figure 6 for a summary of the main findings).

4.1. Language, imagery vividness and gestures in L1 and L2 creativity

Our first hypothesis that people are overall more creative, both in divergent and convergent thinking, and their imagery is more vivid in L1 than in L2, was confirmed. This was expected, given that creativity was assessed through verbal tasks (AUT and RAT), and participants' proficiency in their L1 (Turkish) was likely higher than in their L2 (English). Participants were sequential bilinguals who acquired L2 English after L1 Turkish. Their mean age of L2 exposure and acquisition was around the age of nine. Although sequential bilinguals are usually more proficient in their L1 than L2, the literature shows mixed outcomes. For instance, Kaushanskaya et al. (2011) observed contrasting effects depending on language pairings. English (L1) – Spanish (L2) bilinguals who acquired Spanish later exhibited better L1 vocabulary and reading fluency, whereas English (L1) – Mandarin (L2) bilinguals showed the opposite trend. These findings were attributed to cross-linguistic transfer effects, particularly those involving writing system characteristics. Given the linguistic similarity between Turkish and English (both alphabetic languages), the bilinguals in our study are more comparable to the English-Spanish group in Kaushanskaya et al.'s study. Our findings thus provide additional support for the idea that L2 acquisition, when the writing systems are congruent, may coincide with enhanced L1 verbal performance, at least in tasks involving creative thinking. Although L1 proficiency was not directly measured, all participants were Turkish native speakers, residing in Türkiye, and acquired English later. Therefore, they have high L1 proficiency. Factors like immigration or heritage speaker status, which may lead to L1 attrition or L2 dominance (e.g., Austin et al., 2019), were not relevant to our sample.

The hypothesis that imagery is more vivid in L1 compared to L2 aligns with previous findings (Blazhenkova et al., 2023; Dorfman et al., 2025; Hayakawa & Keysar, 2018; Jansson & Dylman, 2021; Montero-Melis et al., 2020; Oshima & Morishima, 2023). However, it was not related to L2 proficiency, as emphasized by earlier studies (Blazhenkova et al., 2023; Hayakawa & Keysar, 2018). Interestingly, in a recent qualitative study on team creativity in a foreign language (Loderer et al., 2024), participants reported that reduced proficiency

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

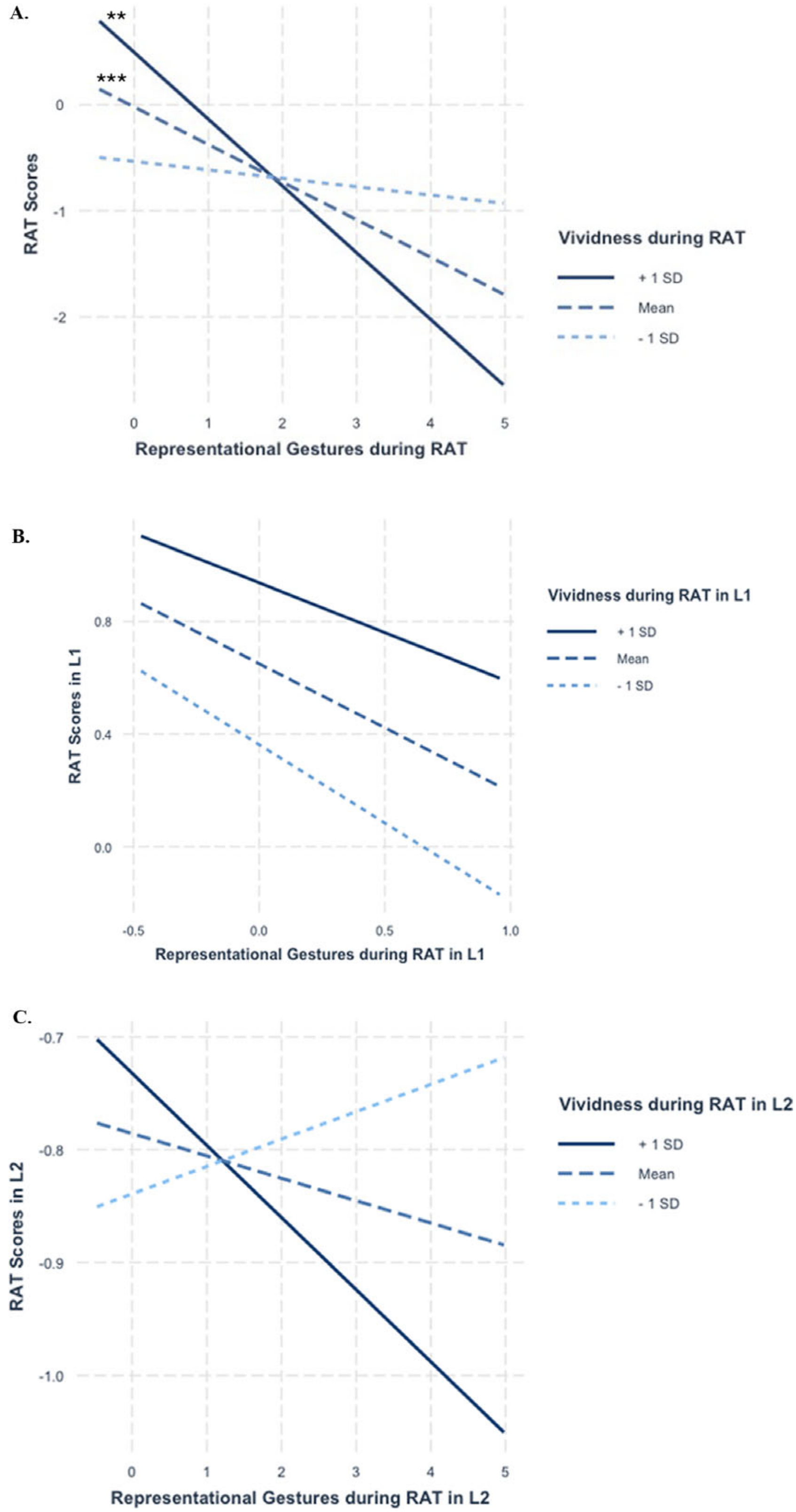

Figure 4. Interaction of Representational Gesture Frequency and Vividness of Mental Imagery on Remote Associates Test (RAT) Scores. (A) This plot illustrates the simple slopes of RAT Representational Gesture Frequency (scaled) at three levels of RAT Vividness (scaled): −1 *SD*, the, *mean*, and +1 *SD*, **for L1 and L2 combined.** Specifically, when RAT Vividness is +1 SD, the slope is steepest and most negative, indicating a stronger negative relationship between gesture frequency and RAT scores. Conversely, at −1 *SD* of RAT Vividness, the slope is less steep and not significant. The slopes for mean and +1*SD* vividness are significant. (B) This plot illustrates the simple slopes of RAT Representational Gesture Frequency (scaled) at three levels of RAT Vividness (scaled) for **L1 (Turkish)**. None of the slopes are significant. (C) This plot illustrates the simple slopes of RAT Representational Gesture Frequency (scaled) at three levels of RAT Vividness (scaled) for **L2 (English).** None of the slopes are significant.

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

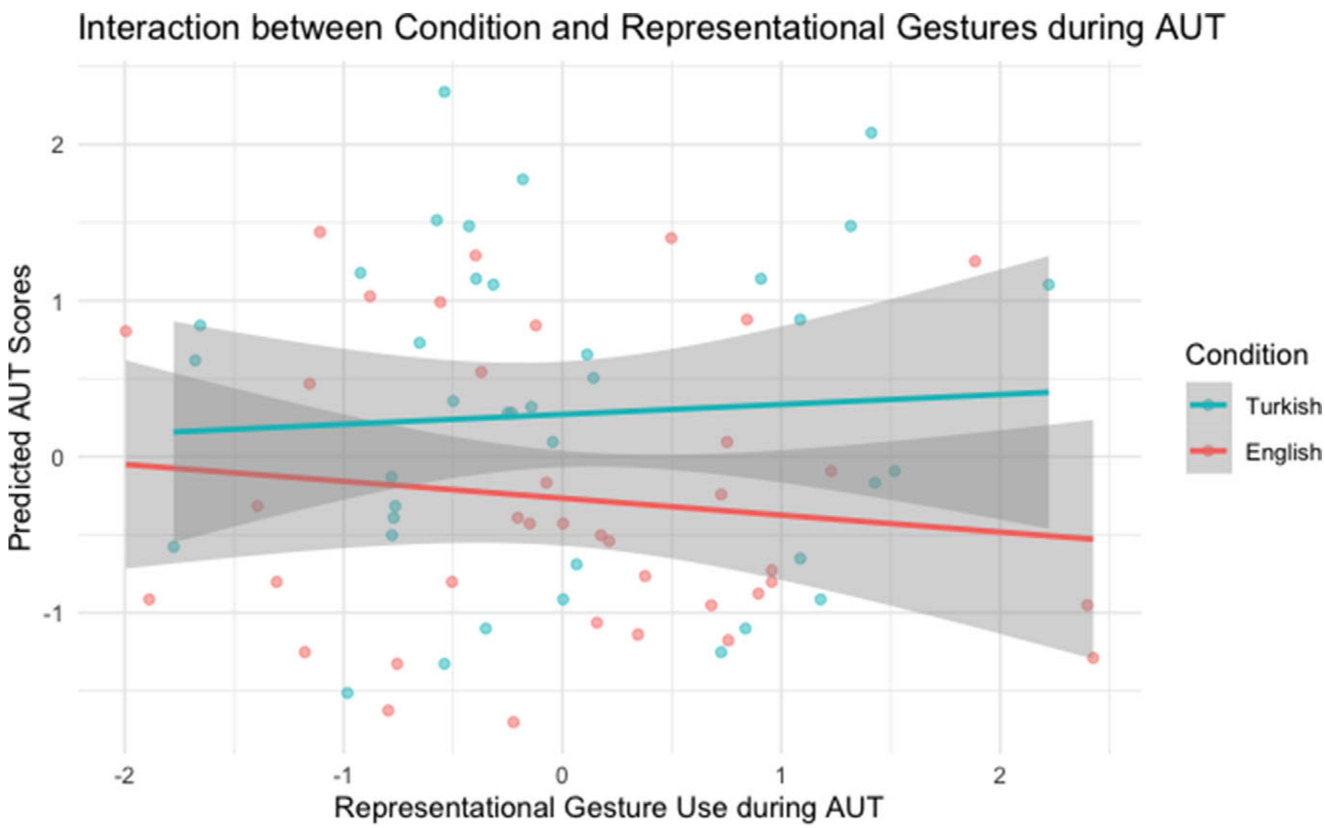

Figure 5. The plot depicts the interaction effect between language condition (English versus Turkish) and representational gesture use during the Alternative Uses Task (AUT) on predicted AUT scores. Shaded areas indicate 95% confidence intervals.

in L2 triggered a more visual thought process that inspired creativity. As these were self-reported personal experiences with creativity, a more controlled experimental setting might be required to test those insights. Nevertheless, we found neither a positive nor a negative association between proficiency and imagery vividness. This could be due to the higher L2 proficiency of our sample (a mean proficiency score of 22 out of 30). For example, Hayakawa and Keysar (2018) found that the effect of language was most pronounced for lower proficiency participants. Moreover, language proficiency moderated the effects on imagery for the auditory and motor modalities but not the visual modality.

Last, people gestured more during L2 than during L1 convergent thinking. Representational gesture rates during L1 and L2 divergent thinking were comparable. The reason why people gestured significantly more during L2 convergent thinking could be related to task difficulty. The RAT (measuring convergent thinking) is considerably more difficult than the AUT (measuring divergent thinking) as it requires one to look for a single correct answer in a very limited amount of time (compare 30 seconds in the RAT to 3 minutes on the AUT). Previous research shows that people use more representational gestures in L2 when they have difficulty expressing abstract notions, such as emotions or metaphorical sentences (Akbuğa & Göksun, under review; Özder et al., 2023). In this study, participants might have also used more gestures during L2 compared to L1 RAT because of increased task difficulty compared to the AUT. However, increased gesture rate in L2 did not lead to higher vividness of imagery or enhanced L2 RAT performance, which will be further discussed in the next sections.

4.2. Representational gestures and vividness of mental imagery during L1 and L2 divergent thinking

Vividness of mental imagery during divergent thinking and L2 proficiency were positively associated with divergent thinking scores irrespective of the language condition. However, when we controlled for the effects of representational gestures, we found a significant two-way interaction between language condition and gestures. Even though the simple slopes of gestures were not significant, there was a tendency for representational gestures in L1 to be positively associated with divergent thinking. In contrast, representational gesture use in L2 was negatively associated with divergent thinking. That is, gestures played different roles in L1 and L2 divergent thinking. Interestingly, the main effect of imagery vividness on divergent thinking persisted, while the effect of L2 proficiency did not. These results demonstrate that when we control for representational gesture use, the effect of L2 proficiency on divergent thinking vanishes, but the effect of imagery vividness persists. Therefore, imagery, along with gestures, might be a more determining factor for divergent thinking success compared to L2 proficiency both in L1 and in L2.

This finding conflicts with Arslan et al. (2024), who found an association between L2 proficiency and representational gesture rates. This could be due to differences in the tasks used. While Arslan et al. (2024) used cartoon narratives that could be related to episodic memory, the creativity tasks we used might depend on semantic memory. The role of semantic memory in creativity stems from a theory that the farther one moves through the semantic memory space of a concept, the more novel and creative one's ideas

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

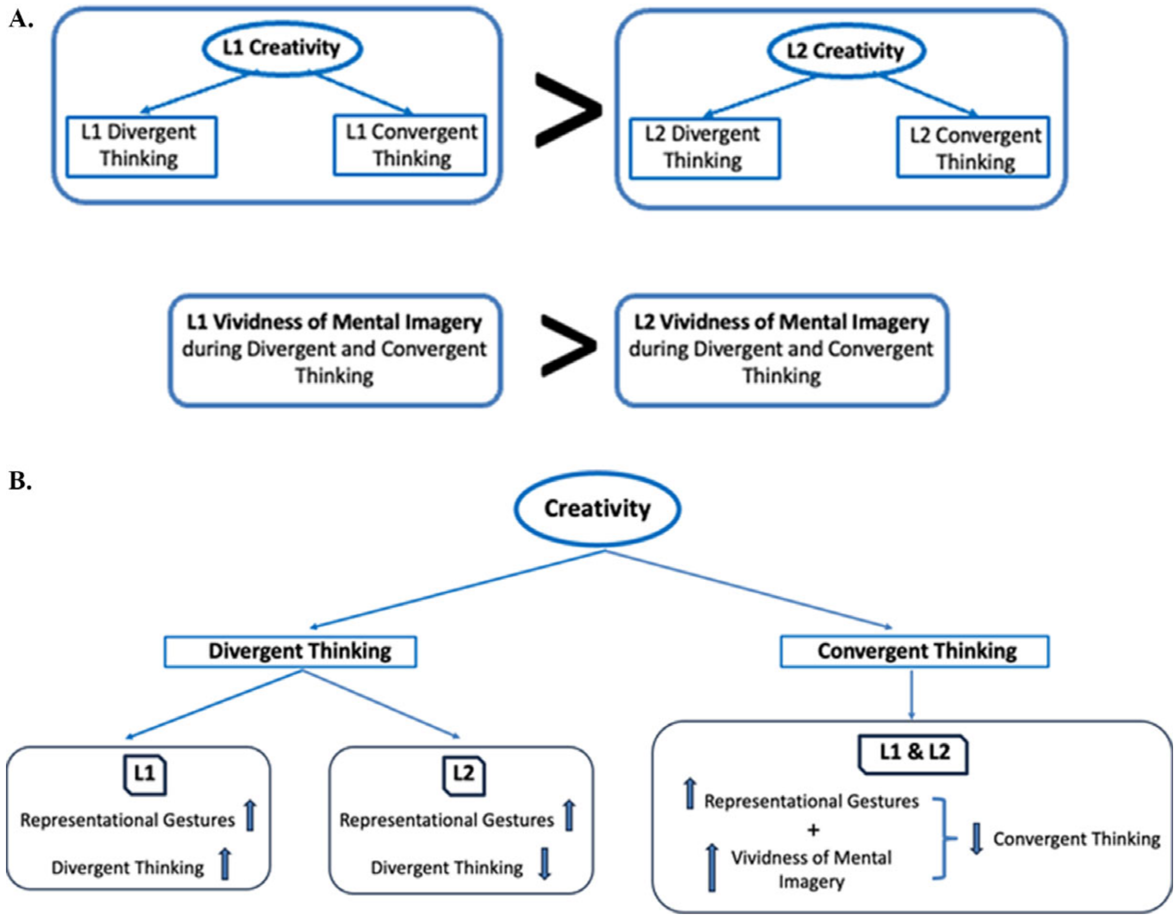

Figure 6. A conceptual diagram summarizing the main findings of the study: (A) Participants were more creative and experienced more vivid mental imagery in L1 than in L2. (B) Gestures in L1 had a positive while gestures in L2 had a negative association with divergent thinking. Higher gesture rates were associated with lower convergent thinking performance in both languages, especially when imagery vividness was high.
Note: L2 proficiency was not associated with creativity or mental imagery vividness.

become (Kenett, 2023). More creative individuals are believed to have more associative links in their semantic memory and, thus, make faster creative connections (Beaty et al., 2023; Kenett & Austerweil, 2016; Luchini et al., 2023). As bilingual semantic memory is believed to be language-independent (Bartolotti & Marian, 2013; Lopez, 2020; Shook & Marian, 2012), L2 proficiency might not have affected gesture use in our tasks. However, recalling general knowledge in bilinguals depended on the language in which the question was asked (Marian & Kaushanskaya, 2007). Moreover, vividness of imagery, even though not interacting with gestures, was more influential for the divergent thinking tasks. The way we measured proficiency in this study also differed from Arslan et al. (2024). We used self-reports of L2 proficiency, while they used a standardized placement test. However, note that another recent study using cartoon narratives for gesture elicitation, and which measured L2 proficiency by certified evaluators, failed to find a relationship between semantic (iconic) gesture production and L2 proficiency (Lopez-Ozieblo, 2024). Further research is required to elucidate the factors affecting the relationship between L2 proficiency and gestures.

Before controlling for the effects of representational gestures, L2 proficiency was a significant predictor of divergent thinking scores not only in L2 but also in L1. This intriguing finding suggests a link between general divergent thinking ability and foreign language proficiency. The direction of causality, however, remains open to debate. According to Sternberg (2002), mastering a new language requires “successful intelligence,” which entails the ability to cope with novelty. Novelty, along with tolerance for ambiguity, is central to creativity (Albert, 2006). Participants with higher divergent thinking skills in our sample would be better equipped to devise novel, effective strategies for learning a second language, leading to higher L2 proficiency. Empirical support for this association comes from earlier studies showing positive correlations between the Torrance Test of Creative Thinking scores and L2 performance (Albert & Kormos, 2004; Ottó & Otto, 1998). More recent research also confirms this relationship (e.g., Fernández-Fontecha, 2021; Li & Wei, 2025; Wu & Qin, 2025). Conversely, higher L2 proficiency might enhance divergent thinking, perhaps due to factors such as enriched conceptual knowledge (Kharkhurin, 2017) or increased exposure to multicultural experiences (Fürst & Grin, 2017, 2021). Supporting this view, a recent neuroimaging study found that L2 proficiency was positively associated with creativity scores on the AUT and a chain-free association task performed in L1 (Yang et al., 2025). The neuroimaging data further indicated a more efficient use of brain resources, evidenced by decreased cortical activation in regions associated with creative cognition, among more proficient bilinguals. These findings point to functional anatomical differences in creative processing based on L2 proficiency. Future research could examine whether individual differences in hand gesture use further modulate activation in these brain regions.

https://doi.org/10.1017/S1366728925100151 Published online by Cambridge University Press

The persisting effect of imagery vividness on AUT performance is consistent with earlier findings, demonstrating an association between self-reported imagery vividness and divergent thinking performance (Le Boutillier & Marks, 2003). Moreover, it might support the qualitative reports of Loderer et al. (2024), where people reported that reduced proficiency in L2 triggered a more visual thought process that inspired creativity. Namely, the assumption that language might be redundant for creativity in the presence of (vivid) imagery. This is also in line with the notion that semantic memory is language-independent (Bartolotti & Marian, 2013; López, 2020; Shook & Marian, 2012), and as the role of semantic memory for creativity has long been emphasized (Beaty et al., 2023), our finding supports the important role of imagery for divergent thinking.

In addition to imagery vividness, we also found an effect of representational gestures for divergent thinking, but unlike the ubiquitous positive association with imagery, the effects of gestures for divergent thinking differed across the language conditions. There was a tendency for gestures to be positively associated with L1 divergent thinking while they were negatively associated with L2 divergent thinking. These trends might tell us that one could be using their gestures in L1 to illustrate their ideas (e.g., for communicative purposes or to visually illustrate/emphasize their ideas), but also their gestures might help them activate those ideas. It is difficult to infer causality from associative relationships. More gesturing in L2 was linked to lower divergent thinking scores. One interpretation is that people used their gestures to illustrate what they could not express in their L2 speech, but that did not help them find the right words or ideas. Gestures might have complemented their speech in L2 but could not facilitate it. Another interpretation is that if people had gestured about the conventional uses of the prompt objects (e.g., reading a newspaper), that might have fixated them on similar uses, restricting their ability to see the prompts from different perspectives (e.g., making a bracelet out of a newspaper or a hat). Hyusein and Göksun (2024b) also suggested a similar fixation effect. Iconic gestures were associated with less flexible ideas in L1. Whether the effect in the current study was driven by the flexibility of ideas rather than the fluency, originality, and elaboration of responses and what people tended to gesture about should be a path for further investigation.

4.3. Representational gestures and vividness of mental imagery during L1 and L2 convergent thinking

Interestingly, even though at first, we detected a significant three-way interaction among gestures, vividness of imagery and L2 proficiency, post-hoc analyses revealed that only the two-way interaction between gestures and vividness was significant. One explanation of this finding is that even though the study had enough statistical power to detect a three-way interaction as per the power analysis we conducted to determine the sample size, the post-hoc analysis might have reduced its power due to the multiple comparisons and adjustments required. On the other hand, this finding corroborates our results on the effects of imagery vividness and L2 proficiency in divergent thinking, namely that the effect of vividness persevered after controlling for the effects of representational gestures, while the effect of L2 proficiency vanished. Hence, L2 proficiency was not a determinant either for divergent or convergent thinking. Future studies could recruit a more diverse L2 proficiency sample to test if proficiency moderates gesture and imagery effects on creativity.

In the present study, the relation between representational gestures and convergent thinking depended on how vivid imagery was during convergent thinking. Higher vividness, along with higher representational gesture use, was related to lower convergent thinking scores irrespective of the language condition. Even though we did not find an effect of language condition, the separate interaction plots for L1 and L2 (see Figure 4B,C) and greater L2 gesture use suggest that this effect of imagery and gestures might be specifically true for L2 convergent thinking. While high imagery vividness could be beneficial for divergent thinking, it might hurt convergent thinking and, together with gestures, lead to a fixation effect similar to gestures in L2 divergent thinking. Another interpretation of this interaction could be that people who knew the answers to the convergent thinking triads did not feel the need to gesture or use their imagery. They might have reached the answers through a faster linguistic path rather than activating imagistic routes. Supporting this, earlier work showed that analytic solutions to remote associate problems led to relatively more incorrect solutions than responses elicited by insight (Salvi et al., 2016).

The finding that representational gestures, especially when one experiences higher imagery vividness during convergent thinking, are in a negative association with RAT scores might seem contradictory to Hyusein and Göksun (2023), who found a positive association between representational gestures and RAT scores for people with high mental imagery skills. However, Hyusein and Göksun (2023) measured mental imagery skills, which were related to the generation, maintenance and manipulation of mental images rather than their vividness. This dissociation implies that mental imagery skills and vividness of self-reported mental imagery might be different concepts and should not be used interchangeably. Such a discrepancy in imagery measurement was also highlighted by Blazhenkova et al. (2023), who found that L1- L2 vividness disparity depended on the way vividness was measured.

4.4. Implications and future directions

The current study contributed to the literature on gestures, creativity and bilingualism by providing new insights into how and why bilingual people might use their hands to think creatively in their native and second language. This is the first study to investigate such effects and the findings expand gesture and creativity frameworks. In particular, we suggest that gestures have a different impact on creative processes when used in L1 versus L2. However, the exact role of gestures should be further investigated. For example, we can study the semantic meaning each gesture conveys to find out whether people express further information that is not expressed in speech with their hands. If their gestures only contain information already provided in speech, this would be evidence of creative fixation. Moreover, we can encourage or restrict people's gestures in L2 and test whether the effects of spontaneous gestures differ.

Another contribution of the current study is the finding that vividness of imagery or L2 proficiency alone might not be a reason for the foreign language effect. The interaction of imagery with hand gestures, in addition to L2 proficiency losing its impact on creativity once we include gestures into the equation, shows that language is indeed multimodal, and gestures are an essential part of it. By studying the semantic information carried by gestures as a next step, we can find out whether gestures complement creative ideas and whether we should consider both speech and hand gestures when evaluating those ideas.

One drawback of this study could be how vividness of imagery during creative thinking was measured. We used self-ratings after each AUT and RAT trial, but this could imply a bidirectional relationship. In particular, people who felt and were more creative might have rated their imagery as more vivid, or people who could not come up with many ideas on the AUT or could not find the right answer on the RAT might have rated their imagery as less vivid. A future study can try to manipulate vividness by instructing a group of people to imagine the stimuli very carefully, similar to Oshima and Morishima (2023), or as vividly as they can, and then compare their performance to another group that is not given such an instruction. These measures can provide a more direct manipulation of imagery vividness.

5. Conclusion

The current study examined differences in creative thinking, mental imagery vividness and representational hand gestures between one's native (L1) and second (L2) languages. Results showed higher creativity and more vivid mental imagery in L1 compared to L2. Contrary to the hypothesis, higher L2 proficiency, along with increased use of representational gestures and higher imagery vividness in L2, did not enhance L2 creativity. Notably, higher representational gesture rates in L1 were linked to higher divergent thinking, while higher gesture rates in L2 were linked to lower divergent thinking. This means that gestures either help L1 but hurt L2 divergent thinking or that better divergent thinkers gesture more in their L1 and poorer divergent thinkers gesture more in their L2. Further research is needed to clarify this distinction. Vividness of mental imagery and L2 proficiency did not affect the interaction between bilingual divergent thinking and representational hand gestures. Vividness, however, did impact the association between convergent thinking and gestures, irrespective of the language context or individuals' L2 proficiency level. Higher gesture rates during convergent thinking were associated with lower convergent thinking performance in both languages, especially when imagery was vivid, which might imply a creative fixation effect.

This study underscores the complex interplay among bilingualism, gestures and creative processes. Our findings suggest that gestures have a varied impact on creative thinking in L1 versus L2 and highlight the need for further research on the semantic content of gestures and their role in creative processes.

Data availability statement. The data that support the findings of this study are openly available in the Open Science Framework: https://osf.io/4paf2/?view_only=9ad2d853d04946da943bcfd19af1a2c1

Acknowledgments. The authors sincerely thank Müjde Altın, Begüm Çallı and Başak Ayaz for their assistance with data collection, gesture coding and creativity ratings, the members at the Language & Cognition Lab and the first author's PhD thesis committee members for their valuable feedback and all the participants for their time and effort. This work was supported by a James S. McDonnell Foundation Scholar Award (Grant Number: https://doi.org/10.37717/220020510) given to Tilbe Göksun.

Competing interests. The authors declare none.

References

Abraham, A. (2016). The imaginative mind. *Human Brain Mapping*, **37**(11), 4197–4211. https://doi.org/10.1002/hbm.23300.

Akbuğa, Y. E., & **Göksun, T.** (in press). Spatial metaphors of time elicit more temporal gestures in a second language. Cognitive Processing.

Albert, Á. (2006). Learner creativity as a potentially important variable: Examining the relationships between learner creativity, language aptitude and level of proficiency. In M. Nikolov & J. Horváth (Eds.), *UPRT 2006: Empirical studies in English applied linguistics* (pp. 77–98). Lingua Franca Csoport.

Albert, Á., & **Kormos, J.** (2004). Creativity and narrative task performance: An exploratory study. *Language Learning*, **54**(2), 277–310. https://doi.org/10.1111/j.1467-9922.2004.00256.x.

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of Personality and Social Psychology*, **43**(5), 997–1013. https://doi.org/10.1037/0022-3514.43.5.997.

Arslan, B., **Avcı, C.**, **Yılmaztekin, A.**, & **Göksun, T.** (2024). Do bilingual adults gesture when they are disfluent?: Understanding gesture-speech interaction across first and second languages. *Language, Cognition and Neuroscience*, **39**(5), 571–583. https://doi.org/10.1080/23273798.2024.2345306.

Artola, T., **Barraca, J.**, **Martin, C.**, **Mosteiro, P.**, **Ancillo, I.**, & **Poveda, B.** (2008). *PIC-J. Prueba de imaginacion creativa para jovenes*. Madrid: TEA Edi-ciones.

Atit, K., **Gagnier, K.**, & **Shipley, T. F.** (2015). Student gestures aid penetrative thinking. *Journal of Geoscience Education*, **63**(1), 66–72.

Austin, L., **Hernandez, A. E.**, & **Schwieter, J. W.** (2019). *Proficiency Predictors in Sequential Bilinguals: The Proficiency Puzzle*. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108641395.

Bartolotti, J., & **Marian, V.** (2013). Bilingual memory: Structure, access, and processing. In J. Altarriba & L. Isurin (Eds.), *Memory, language, and bilingualism: Theoretical and applied approaches* (pp. 7–48). CUP.

Beaty, R. E., **Kenett, Y. N.**, **Hass, R. W.**, & **Schacter, D. L.** (2023). Semantic memory and creativity: The costs and benefits of semantic memory structure in generating original ideas. *Thinking and Reasoning*, **29**(2), 305–339. https://doi.org/10.1080/13546783.2022.2076742.

Bergmann, K., **Aksu, V.**, & **Kopp, S.** (2011). The relation of speech and gestures: Temporal synchrony follows semantic synchrony. In *Proceedings of the 2nd workshop on gesture and speech in interaction*, September 5–7, 2011, GeSpIn, Bielefeld, Germany. https://pub.uni-bielefeld.de/download/2392953/2410339/Bergmann_Aksu_Kopp2011.pdf

Bialystok, E. (2021). Bilingualism as a slice of Swiss cheese. *Frontiers in Psychology*, **12**, 769323. https://doi.org/10.3389/fpsyg.2021.769323.

Birba, A., **Beltrán, D.**, **Caro, M. M.**, **Trevisan, P.**, **Kogan, B.**, **Sedeño, L.**, **Ibáñez, A.**, & **García, A. M.** (2020). Motor-system dynamics during naturalistic reading of action narratives in first and second language. *NeuroImage*, **216**, 116820. https://doi.org/10.1016/j.neuroimage.2020.116820.

Blazhenkova, O., **Kanero, J.**, **Duman, I.**, & **Umitli, O.** (2023). Read and imagine: Visual imagery experience evoked by first versus second language. *Psychological Reports*, **128**(2), 1067–1100. https://doi.org/10.1177/00332941231158059.

Caldwell-Harris, C. L. (2014). Emotionality differences between a native and foreign language: Theoretical implications. *Frontiers in Psychology*, **5**, 1–4. https://doi.org/10.3389/fpsyg.2014.01055.

Caldwell-Harris, C. L., & **Ayçiçeği-Dinn, A.** (2009). Emotion and lying in a non-native language. *International Journal of Psychophysiology*, **71**(3), 193–204. https://doi.org/10.1016/j.ijpsycho.2008.09.006.

Chun, C. A., & **Hupé, J.** (2015). Are synesthetes exceptional beyond their synesthetic associations? A systematic comparison of creativity, personality, cognition, and mental imagery in synesthetes and controls. *British Journal of Psychology*, **107**(3), 397–418. https://doi.org/10.1111/bjop.12146.

Corey, J. D., **Hayakawa, S.**, **Foucart, A.**, **Aparici, M.**, **Botella, J.**, **Costa, A.**, & **Keysar, B.** (2017). Our moral choices are foreign to us. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, **43**(7), 1109–1128. https://doi.org/10.1037/xlm0000356.

Costa, A., **Foucart, A.**, **Arnon, I.**, **Aparici, M.**, & **Apesteguia, J.** (2014). "Piensa" twice: On the foreign language effect in decision making. *Cognition*, **130**(2), 236–254. https://doi.org/10.1016/j.cognition.2013.11.010.

De Dreu, C. K. W., **Baas, M.**, & **Nijstad, B. A.** (2008). Hedonic tone and activation level in the mood-creativity link: Toward a dual pathway to creativity model. *Journal of Personality and Social Psychology*, **94**(5), 739–756. https://doi.org/10.1037/0022-3514.94.5.739.

Dewaele, J. (2010). *Emotions in multiple languages*. Palgrave Macmillan UK eBooks. https://doi.org/10.1057/9780230289505.

Dorfman, F. T., **Kogan, B.**, **Barttfeld, P.**, & **García, A. M.** (2025). Bilinguals on the footbridge: The role of foreign-language proficiency in moral decision making. *Bilingualism: Language and Cognition*, **28**(3), 816–831. https://doi.org/10.1017/s1366728924000312

Dylman, A. S., & **Bjärtå, A.** (2018). When your heart is in your mouth: The effect of second language use on negative emotions. *Cognition and Emotion*, **33**(6), 1284–1290. https://doi.org/10.1080/02699931.2018.1540403.

Estremera, R., & **Torres, J.** (2014). Psychosocial factors and types of linguistic knowledge in heritage speakers. Paper presented at the 2014 Second Language Research Forum, Columbia, SC.

Faul, F., **Erdfelder, E.**, **Buchner, A.**, & **Lang, A.** (2009). Statistical power analyses using G*power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, **41**(4), 1149–1160. https://doi.org/10.3758/brm.41.4.1149.

Fernández-Fontecha, A. (2021). The role of learner creativity in L2 semantic fluency. An exploratory study. *System*, **103**, 102658. https://doi.org/10.1016/j.system.2021.102658.

Fernández-Fontecha, A., & **Kenett, Y. N.** (2022). Examining the relations between semantic memory structure and creativity in second language. *Thinking Skills and Creativity*, **45**, 101067. https://doi.org/10.1016/j.tsc.2022.101067.

Finke, R. A., **Ward, T. B.**, & **Smith, S. M.** (1992). *Creative cognition: Theory, research, and applications*. A Bradford Book.

Friedlander, K. J., **Lenton, F. H.**, & **Fine, P. A.** (2024). A multifactorial model of visual imagery and its relationship to creativity and the vividness of visual imagery questionnaire. *Psychology of Aesthetics, Creativity, and the Arts*, **18** (5), 829–847. https://doi.org/10.1037/aca0000520.

Fürst, G., & **Grin, F.** (2017). Multilingualism and creativity: A multivariate approach. *Journal of Multilingual and Multicultural Development*, **39**(4), 341–355. https://doi.org/10.1080/01434632.2017.1389948.

Fürst, G., & **Grin, F.** (2021). Multicultural experience and multilingualism as predictors of creativity. *International Journal of Bilingualism*, **25**(5), 1486–1494. https://doi.org/10.1177/13670069211019468.

Georgiev, G. V., & **Taura, T.** (2014). Polysemy in Design Review Conversations. DTRS 10: Design Thinking Research Symposium 2014 – Purdue University. https://doi.org/10.5703/1288284315936.

Ghonsooly, B., & **Showqi, S.** (2012). The effects of foreign language learning on creativity. *English Language Teaching*, **5**(4), 161–167 . https://doi.org/10.5539/elt.v5n4p161.

Gocłowska, M. A., **Crisp, R. J.**, & **Labuschagne, K.** (2012). Can counter-stereotypes boost flexible thinking? *Group Processes & Intergroup Relations/Group Processes and Intergroup Relations*, **16**(2), 217–231. https://doi.org/10.1177/1368430212445076.

Guilford, J. P. (1950). Creativity. *American Psychologist*, **5**, 444–454.

Guilford, J. P. (1967). *The nature of human intelligence* (1st ed.). McGraw-Hill.

Harris, C. L., **Ayçiçeği, A.**, & **Gleason, J. B.** (2003). Taboo words and reprimands elicit greater autonomic reactivity in a first language than in a second language. *Applied PsychoLinguistics*, **24**(4), 561–579. https://doi.org/10.1017/s0142716403000286.

Hayakawa, S., & **Keysar, B.** (2018). Using a foreign language reduces mental imagery. *Cognition*, **173**, 8–15. https://doi.org/10.1016/j.cognition.2017.12.010.

Hayakawa, S., **Tannenbaum, D.**, **Costa, A.**, **Corey, J. D.**, & **Keysar, B.** (2017). Thinking more or feeling less? Explaining the foreign-language effect on moral judgment. *Psychological Science*, **28**(10), 1387–1397. https://doi.org/10.1177/0956797617720944.

Hommel, B., **Colzato, L. S.**, **Fischer, R.**, & **Christoffels, I. K.** (2011). Bilingualism and creativity: Benefits in convergent thinking come with losses in divergent thinking. *Frontiers in Psychology*, **2**(273), 1–5. https://doi.org/10.3389/fpsyg.2011.00273.

Hostetter, A. B., & **Alibali, M. W.** (2008). Visible embodiment: Gestures as simulated action. *Psychonomic Bulletin & Review*, **15**(3), 495–514. https://doi.org/10.3758/pbr.15.3.495.

Hyusein, G., & **Göksun, T.** (2023). The creative interplay between hand gestures, convergent thinking, and mental imagery. *PLoS One*, **18**(4), e0283859. https://doi.org/10.1371/journal.pone.0283859.

Hyusein, G., & **Göksun, T.** (2024b). Give your ideas a hand: The role of iconic hand gestures in enhancing divergent creative thinking. *Psychological Research*, **88**(4), 1298–1313. https://doi.org/10.1007/s00426-024-01932-1

Jansson, B., & **Dylman, A. S.** (2021). Reduced vividness of emotional memories following reactivation in a second language. *Cognition and Emotion*, **35**(6), 1222–1230.

Jared, D., **Poh, R. P. Y.**, & **Paivio, A.** (2012). L1 and L2 picture naming in mandarin–English bilinguals: A test of bilingual dual coding theory. *Bilingualism*, **16**(2), 383–396. https://doi.org/10.1017/s1366728912000685.

Kamermans, K. L., **Pouw, W.**, **Fassi, L.**, **Aslanidou, A.**, **Paas, F.**, & **Hostetter, A. B.** (2019). The role of gesture as simulated action in reinterpretation of mental imagery. *Acta Psychologica*, **197**, 131–142. https://doi.org/10.1016/j.actpsy.2019.05.004.

Kaushanskaya, M., **Yoo, J.**, & **Marian, V.** (2011). *The effect of Second-Language experience on Native-Language processing.* PubMed. https://pubmed.ncbi.nlm.nih.gov/23125864

Kenett, Y. N. (2023). Creatively searching through semantic memory structure: A short integrative review. In L. J. Ball & F. Vallée-Tourangeau (Eds.), *The Routledge International Handbook of Creative Cognition*, 160–179. Routledge. https://doi.org/10.4324/9781003009351-13.

Kenett, Y. N., & **Austerweil, J. L.** (2016). Examining search processes in low and high creative individuals with random walks. In A. Papafragou, D. G rodner, D. Mirman & J. C. Trueswell (Eds.), *Proceedings of the 38th annual meeting of the cognitive science society*, 313–318. Cognitive Science Society.

Keysar, B., **Hayakawa, S. L.**, & **An, S. G.** (2012). The foreign-language effect. *Psychological Science*, **23**(6), 661–668. https://doi.org/10.1177/0956797611432178.

Kharkhurin, A. V. (2007). The role of cross-linguistic and cross-cultural experiences in bilinguals' divergent thinking. In I. Kecskes & L. Albertazzi (Eds.), *Cognitive aspects of bilingualism*, 175–210. Springer. https://doi.org/10.1007/978-1-4020-5935-3_6.

Kharkhurin, A. V. (2008). The effect of linguistic proficiency, age of second language acquisition, and length of exposure to a new cultural environment on bilinguals' divergent thinking. *Bilingualism Language and Cognition*, **11**(2), 225–243. https://doi.org/10.1017/s1366728908003398.

Kharkhurin, A. V. (2011). The role of selective attention in bilingual creativity. *Creativity Research Journal*, **23**(3), 239–254. https://doi.org/10.1080/10400419.2011.595979.

Kharkhurin, A. V. (2017). Language mediated concept activation in bilingual memory facilitates cognitive flexibility. *Frontiers in Psychology*, **8**, 1–16. https://doi.org/10.3389/fpsyg.2017.01067.

Kharkhurin, A. V., & **Wei, L.** (2014). The role of code-switching in bilingual creativity. *International Journal of Bilingual Education and Bilingualism*, **18**(2), 153–169. https://doi.org/10.1080/13670050.2014.884211.

Kirk, E., & **Lewis, C.** (2017). Gesture facilitates children's creative thinking. *Psychological Science*, **28**(2), 225–232. https://doi.org/10.1177/0956797616679183.

Kita, S., **Alibali, M. W.**, & **Chu, M.** (2017). How do gestures influence thinking and speaking? The gesture-for-conceptualization hypothesis. *Psychological Review*, **124**(3), 245–266. https://doi.org/10.1037/rev0000059.

Kosslyn, S. M. (1982). Image and mind. *Poetics Today*, **3**(1), 198. https://doi.org/10.2307/1772225.

Kosslyn, S. M. (1994). Image and brain: The resolution of the imagery debate. http://ci.nii.ac.jp/ncid/BA28949474

Kosslyn, S. M., **Thompson, W. L.**, & **Ganis, G.** (2006). *The case for mental imagery*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195179088.001.0001.

Krasny, K. A., & **Sadoski, M.** (2008). Mental imagery and affect in English/French bilingual readers: A cross-linguistic perspective. *Canadian Modern Language Review*, **64**(3), 399–428.

Krauss, R. M. (1998). Why do we gesture when we speak? *Current Directions in Psychological Science*, **7**(2), 54. https://doi.org/10.1111/1467-8721.ep13175642.

Lange, K. V., **Hopman, E. W. M.**, **Zemla, J. C.**, & **Austerweil, J. L.** (2020). Evidence against a relation between bilingualism and creativity. *PLoS One*, **15**(6), e0234928. https://doi.org/10.1371/journal.pone.0234928.

Le Boutillier, N., & **Marks, D. F.** (2003). Mental imagery and creativity: A meta-analytic review study. *British Journal of Psychology*, **94**(1), 29–44. https://doi.org/10.1348/000712603762842084.

Lee, H., & **Kim, K. H.** (2010). Relationships between bilingualism and adaptive creative style, innovative creative style, and creative strengths among Korean American students. *Creativity Research Journal*, **22**(4), 402–407. https://doi.org/10.1080/10400419.2010.523409.

Li, C., & **Wei, L.** (2025). The enhancement of creativity through foreign language learning: Do personality traits matter? *Bilingualism Language and Cognition*, **28**(2), 510–521. https://doi.org/10.1017/s1366728924000476

Loderer, A., **Muehlfeld, K.**, **Wilken, R.**, **Moritz, A.**, & **Slomski, V.** (2024). The language barrier as a springboard towards (team) creativity: An exploratory study of foreign language use in teams. *International Business Review*, **33**(2), 102247. https://doi.org/10.1016/j.ibusrev.2023.102247.

López, E. M. D. (2020). A bilingual advantage in memory capacity: Assessing the roles of proficiency, number of languages acquired and age of acquisition. *International Journal of Bilingualism*, **25**(3), 606–621. https://doi.org/10.1177/1367006920965714.

Lopez-Ozieblo, R. (2024). *Is personality reflected in the gestures of second language speakers? Frontiers in Psychology*, **15**. 1463063. https://doi.org/10.3389/fpsyg.2024.1463063

Luchini, S., **Kenett, Y. N.**, **Zeitlen, D. C.**, **Christensen, A. P.**, **Ellis, D. M.**, **Brewer, G. A.**, & **Beaty, R. E.** (2023). Convergent thinking and insight problem solving relate to semantic memory network structure. *Thinking Skills and Creativity*, **48**, 101277. https://doi.org/10.1016/j.tsc.2023.101277.

Maciejewski, G., **Taylor, J. E.**, & **Klepousniotou, E.** (2023). Type of polysemy matters: Evidence from semantic relatedness decisions. PsyArXiv. https://doi.org/10.31234/osf.io/f8xys

Marian, V., **Blumenfeld, H. K.**, & **Kaushanskaya, M.** (2007). The language experience and proficiency questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research*, **50**(4), 940–967. https://doi.org/10.1044/1092-4388(2007/067).

Marian, V., & **Fausey, C. M.** (2006). Language-dependent memory in bilingual learning. *Applied Cognitive Psychology*, **20**(8), 1025–1047. https://doi.org/10.1002/acp.1242.

Marian, V., & **Kaushanskaya, M.** (2007). Language context guides memory content. *Psychonomic Bulletin & Review*, **14**(5), 925–933. https://doi.org/10.3758/bf03194123.

McAvinue, L. P., & **Robertson, I. H.** (2007). Measuring visual imagery ability: A review. *Imagination, Cognition and Personality*, **26**(3), 191–211. https://doi.org/10.2190/3515-8169-24J8-7157.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. University of Chicago Press.

Mednick, S. (1962). The associative basis of the creative process. *Psychological Review*, **69**(3), 220–232. https://doi.org/10.1037/h0048850.

Montero-Melis, G., **Isaksson, P.**, **van Paridon, J.**, & **Ostarek, M.** (2020). Does using a foreign language reduce mental imagery? *Cognition*, **196**, 104134. https://doi.org/10.1016/j.cognition.2019.104134.

Nicoladis, E. (2007). The effect of bilingualism on the use of manual gestures. *Applied PsychoLinguistics*, **28**(3), 441–454. https://doi.org/10.1017/s0142716407070245.

Nothelfer, S., & **Nothelfer, S.** (2020). Foreign language effects on creativity. *In Innovation und Entrepreneurship*, 47–72. https://doi.org/10.1007/978-3-658-31853-6_3

Oshima, M. R., & **Morishima, Y.** (2023). *The effects of mental imagery on moral dilemmas in a second language*. Authorea Preprints. DOI: 10.22541/au.168245328.83604009/v2

Ottó, I., & **Otto, I.** (1998). The relationship between individual differences in learner creativity and language learning success. *TESOL Quarterly*, **32**(4), 763. https://doi.org/10.2307/3588011.

Özder, L. E., **Özer, D.**, & **Göksun, T.** (2023). Gesture use in L1-Turkish and L2-English: Evidence from emotional narrative retellings. *Quarterly Journal of Experimental Psychology*, **76**(8), 1797–1816. https://doi.org/10.1177/17470218221126685.

Özer, D., & **Göksun, T.** (2020). Gesture use and processing: A review on individual differences in cognitive resources. *Frontiers in Psychology*, **11**, 573555. https://doi.org/10.3389/fpsyg.2020.573555.

Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review*, **76**(3), 241–263. https://doi.org/10.1037/h0027272.

Palmiero, M., **Piccardi, L.**, **Giancola, M.**, **Nori, R.**, **D'Amico, S.**, & **Olivetti Belardinelli, M.** (2019). The format of mental imagery: From a critical review to an integrated embodied representation approach. *Cognitive Processing*, **20**, 277–289.

Pavlenko, A. (2005). *Emotions and multilingualism*. New York: Cambridge University Press.

Pylyshyn, Z. W. (1979). The rate of "mental rotation" of images: A test of a holistic analogue hypothesis. *Memory & Cognition*, **7**(1), 19–28. https://doi.org/10.3758/bf03196930.

Pylyshyn, Z. W. (1981). The imagery debate: Analogue media versus tacit knowledge. *Psychological Review*, **88**(1), 16–45. https://doi.org/10.1037/0033-295X.88.1.16.

Pylyshyn, Z. W. (2002). Mental imagery: In search of a theory. *Behavioral and Brain Sciences*, **25**(2), 157–238. https://doi.org/10.1017/S0140525X02000043.

Rabia, S. A., & **Alattawna, Y.** (2022). Advantages of bilinguals over monolinguals: Creativity among bilingual Arabic—Hebrew Arab students. *Creative Education*, **13**(05), 1643–1666. https://doi.org/10.4236/ce.2022.135104.

R Core Team, R. (2013). R: A language and environment for statistical computing.

Salvi, C., & **Bowden, E. M.** (2016). Looking for creativity: Where do we look when we look for new ideas? *Frontiers in Psychology*, **7**, 161. https://doi.org/10.3389/fpsyg.2016.00161.

Salvi, C., **Bricolo, E.**, **Kounios, J.**, **Bowden, E.**, & **Beeman, M.** (2016). Insight solutions are correct more often than analytic solutions. *Thinking and Reasoning*, **22**(4), 443–460. https://doi.org/10.1080/13546783.2016.1141798.

Sassenberg, K., & **Moskowitz, G. B.** (2005). Don't stereotype, think different! Overcoming automatic stereotype activation by mindset priming. *Journal of Experimental Social Psychology*, **41**(5), 506–514. https://doi.org/10.1016/j.jesp.2004.10.002.

Shook, A., & **Marian, V.** (2012). The bilingual language interaction network for comprehension of speech. *Bilingualism*, **16**(2), 304–324. https://doi.org/10.1017/s1366728912000466.

Sio, U. N., **Kotovsky, K.**, & **Cagan, J.** (2021). Determinants of creative thinking: The effect of task characteristics in solving remote associate test problems. *Thinking & Reasoning*, **28**(2), 163–192. https://doi.org/10.1080/13546783.2021.1959400.

Smith, S. M., **Ward, T. B.**, & **Finke, R. A.** (1995). *The creative cognition approach (Bradford books)* (1st ed.). The MIT Press.

So, W., **Kita, S.**, & **Goldin-Meadow, S.** (2009). Using the hands to identify who does what to whom: Gesture and speech go hand-in-hand. *Cognitive Science*, **33**(1), 115–125. https://doi.org/10.1111/j.1551-6709.2008.01006.x.

So, W. C., **Sim Chen-Hui, C.**, & **Low Wei-Shan, J.** (2012). Mnemonic effect of iconic gesture and beat gesture in adults and children: Is meaning in gesture important for memory recall? *Language and Cognitive Processes*, **27**(5), 665–681. https://doi.org/10.1080/01690965.2011.573220.

Stephan, E. (2017). The influence of a foreign versus native language on creativity. *Creativity Research Journal*, **29**(4), 426–432. https://doi.org/10.1080/10400419.2017.1376544.

Sternberg, R. J. (2002). Intelligence is not just inside the head: The theory of successful intelligence, in *Improving academic achievement* (pp. 227–244). Academic Press.

Torrance, E. P. (1990). *The Torrance tests of creative thinking norms—Technical manual figural (streamlined) forms A & B*. Bensenville, IL: Scholastic Testing Service, Inc.

Vaid, J., **López, B. G.**, & **Martínez, F. E.** (2015). Linking the figurative to the creative: Bilinguals' comprehension of metaphors, jokes, and remote associates. *Bilingual figurative language processing*, 53–86. doi:10.1017/CBO9781139342100.006.

Van Dijk, M., **Kroesbergen, E. H.**, **Blom, E.**, & **Leseman, P. P. M.** (2018). Bilingualism and creativity: Towards a situated cognition approach. *Journal of Creative Behavior/the Journal of Creative Behavior*, **53**(2), 178–188. https://doi.org/10.1002/jocb.238.

Wesp, R., **Hesse, J.**, **Keutmann, D.**, & **Wheaton, K.** (2001). Gestures maintain spatial imagery. *The American Journal of Psychology*, **114**(4), 591. https://doi.org/10.2307/1423612.

Wu, W., & **Qin, J.** (2025). Creativity, topic familiarity, and L2 performance in story continuation writing tasks. *International Journal of Applied Linguistics*. Advance online publication https://doi.org/10.1111/ijal.12737.

Yang, Y., **Li, Y.**, & **Gu, J.** (2025). The neural mechanisms of bilinguals' creativity: A neuroimaging study. *Journal of Neurolinguistics*, **74**, 101245. https://doi.org/10.1016/j.jneuroling.2025.101245.

Zeman, A., **Milton, F.**, **Della Sala, S.**, **Dewar, M.**, **Frayling, T.**, **Gaddum, J.**, **Hattersley, A.**, **Heuerman-Williamson, B.**, **Jones, K.**, **MacKisack, M.**, & **Winlove, C.** (2020). Phantasia–the psychological significance of lifelong visual imagery vividness extremes. *Cortex*, **130**, 426–440. https://doi.org/10.1016/j.cortex.2020.04.003.

Zvaigzne, M., **Oshima-Takane, Y.**, & **Hirakawa, M.** (2019). How does language proficiency affect children's iconic gesture use? *Applied PsychoLinguistics*, **40**(2), 555–583. https://doi.org/10.1017/s014271641800070x.