T.C.
ISTANBUL MEDIPOL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
MASTER'S THESIS

THE ROLE OF VISUAL AND VERBAL WORKING MEMORY ON EPISODIC FUTURE THINKING
(GÖRSEL VE SÖZEL ÇALIŞAN BELLEĞİN EPİZODİK GELECEK DÜŞÜNCESİ ÜZERİNDEKİ ROLÜ)

BURAK YILDIRIM
PSYCHOLOGY MASTER'S PROGRAM

SUPERVISOR
Assoc. Prof. AYSU MUTLUTÜRK

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ÖZET

Epizodik gelecek düşüncesi, gelecekteki olayların zihinsel simülasyonlarını ifade etmektedir. Yapılan çalışmalar çalışan belleğin epizodik gelecek düşüncesine katkılarını incelemiş olsa da, çalışan bellek bileşenlerinin rolü belirsiz kalmıştır. Ayrıca, ilgili bileşenlerin epizodik bellek ve epizodik gelecek düşüncesinde farklı roller oynayıp oynamadığı henüz bilinmemektedir. Bu çalışmanın amacı, görsel ve sözel çalışan bellek bileşenlerinin epizodik gelecek düşüncesine farklı şekilde katkıda bulunup bulunmadığını ve bu bileşenlerin katkılarının zamansal yönler arasında farklılık gösterip göstermediğini çalışan bellek kapasitesini kontrol ederek araştırmaktır. Bu amaçla, bir ikili görev paradigması kullanılarak insanlardan eş zamanlı bir şekilde görsel ve sözel çalışan bellek görevleri yaparken geçmişten ve gelecekten belirgin bir olay hatırlamaları/kurgulamaları istenmiştir. Olayların oluşturulma süreleri (tepki süresi) ve hatırlanan/kurgulanan olayların fenomenolojik değerlendirmeleri analiz edilmiştir. Tepki süresi bulguları, çalışan bellek bileşenlerinin gelecekteki olayları oluşturma aşamasında farklılık göstermediğini, ancak geçmiş olaylar için farklılık gösterdiğini ortaya koymuştur. Buna göre görsel çalışan bellek yükü geçmişten bir olay oluşturma süresini sözel çalışan bellek yüküne kıyasla daha yavaşlatmaktadır. Bununla birlikte, fenomenoloji bulguları geleceği kurgulamanın sözel bileşene kıyasla görsel bileşenle daha çok ilişkili olduğunu göstermektedir. Bulgular görsel çalışan bellek yükünün gelecek düşüncelerinin duygusal yoğunluğunu ve kişisel önemini zayıflattığına işaret etmektedir. Genel olarak, elde ettiğimiz sonuçlar görsel çalışan belleğin epizodik gelecek düşüncesi ve epizodik belleği farklı zamanlarda desteklediğini göstermiştir. Buna göre, görsel çalışan bellek bileşeni epizodik belleğin akla getirilme aşamasına destek sağlarken epizodik gelecek düşüncelerinin detaylandırılma aşamasına katkı sağlamaktadır.

Anahtar Sözcükler: çalışan bellek bileşenleri, epizodik bellek, epizodik gelecek düşüncesi, ikili görev paradigması, zihinsel zaman yolculuğu

ABSTRACT

Episodic future thinking refers to the mental simulations of future events. While previous studies have examined the contribution of working memory on episodic future thinking, the specific role of its components has remained unclear. Additionally, whether these components play distinct roles in episodic memory and episodic future thinking has yet to be clarified. The aim of this study was to investigate whether visual and verbal working memory components contribute differently to episodic future thinking and whether component utilization differs across temporal directions while controlling the effects of working memory capacity. To this end, a dual-task paradigm was employed in which participants were asked to remember past and imagine future events, while simultaneously performing either visual or verbal 2-back tasks, in single and dual-task conditions. The reaction times for event constructions and the phenomenological ratings of these remembered/imagined events were analyzed. The reaction time findings revealed that working memory components did not differ in constructing future events, but they did differ for past events, with visual working memory playing a more important role than verbal working memory. However, a reversed pattern emerged in the emotional intensity and personal importance, with imagined future events being more influenced by visual working memory load. Overall, visual working memory supports the construction phase of episodic memory while contributing to the elaboration phase of episodic future thinking. These findings highlight the pivotal role of visual working memory in remembering the past and imagining future events.

Key Words: dual-task paradigm, episodic future thinking, episodic memory, mental time travel, working memory components

Turkish Extended Summary (Türkçe Genişletilmiş Özet)

GİRİŞ

1. Genel Bakış

Epizodik gelecek düşüncesi, insanların geleceğe yönelik zihinsel kurgular ve simülasyonlar oluşturmasını sağlayan bir yetidir (Atance ve O'Neill, 2001; D'Argembeau vd., 2016; Schacter vd., 2017; Szpunar ve Radvansky, 2016). Bugüne kadar yapılan çalışmalar bu yetinin amaç ve hedeflerin kurgulanması, planlanması ve izlenmesinden (D'Argembeau ve Demblon, 2012; Demblon ve D'Argembeau, 2014), sağlıkla ilgili karar verme süreçlerine (Laywer ve Mahoney, 2018; Segovia vd., 2020; Stein vd., 2018) ve öz düzenlemeye (Salgado ve Berntsen, 2019) kadar birçok bilişsel, davranışsal ve duygusal süreçte rol oynadığını göstermiştir. Epizodik gelecek düşüncesinin altında yatan mekanizmaları anlamak için semantik bilgilerin gelecek hakkında düşünebilmeye katkısı, düşüncelerin duygusal değerliği, yapısı ve organizasyonu gibi çeşitli faktörler incelenmiştir (örn., Schacter, Gaesser ve Addis, 2013; D'argembeau ve Van der Linden, 2004; Puig ve Szpunar, 2017; D'argembeau ve Demblon, 2012). Ancak çalışan belleğin gelecek düşüncesi üzerindeki rolünü inceleyen çalışmalar henüz oldukça sınırlıdır. Çalışan bellek en genel haliyle bilgiyi depolamayı, kısa süreliğine tutmayı, manipüle etmeyi ve geri çağırmayı sağlayan bilişsel bir fonksiyondur. Çalışan belleğin mekanizmasını açıklamak için birçok model ortaya konmuştur (örn., Baddeley ve Hitch, 1974; Cowan, 1988; Oberauer, 2002). Örneğin, çalışan belleği uzun süreli bellekte gömülü bilgilerin aktif hale getirilmiş kısmı olarak ele alan gömülü bellek modelleri (örn., Awh ve Vogel, 2020; Cowan, 1988; Oberauer, 2002) ağırlıklı olarak çalışan bellekle uzun süreli belleğin etkileşimine odaklanırlar. Çalışan belleğin çok bileşenli modelleri ise özellikle son yıllarda bu bütüncül bakış açısına yaklaşmış olmakla birlikte (Bkz. Baddeley, 2000), belleğin tek parçalı bir sistem olmadığını, farklı türdeki (örn., görsel ve sözel) bilgileri işleyen, birbiriyle ilişkili ama birbirinden bağımsız bileşenlerden oluştuğunu ileri sürerler (örn., Baddeley ve Hitch, 1974; Baddeley, 2000). Buna göre, çalışan belleğin bileşenlerinden biri olan fonolojik döngü (phonological loop), sözel ve işitsel bilginin zihinde tutulup manipüle edilebilmesini sağlar. Görsel-uzamsal karalama tahtası (visuo-spatial sketchpad) ise en genel haliyle bir objenin renginin, şeklinin, boyutunun veya konumunun zihinde tutulup manipüle edilmesini sağlar. Çalışan belleğin diğer iki bileşeni ise merkezi yürütücü ve epizodik tampondur. Merkezi yürütücü, dikkat kaynağını yönlendirerek çalışan bellek bileşenlerini koordine eder. Epizodik tampon ise fonolojik döngü, görsel-uzamsal karalama tahtası ve uzun süreli bellekten gelen bilgilerin toplanıp birleştirildiği geçici bir depolama alanı olarak düşünülür. Bu modelin çok bileşenli yapısı, araştırmacıların çeşitli bilişsel süreçlerde (örn., epizodik bellek; Plancher, Gyselink ve Piolino, 2018; problem çözme; Raghubar, Barnes ve Hecht, 2010; anlama; Woolley, 2010) bu bileşenlerin rolünü incelemelerine olanak tanır. Bu doğrultuda yapılan çalışma, çalışan belleğin çok bileşenli modeliyle uyumlu olarak, çalışan belleğin görsel ve sözel bileşenleri ile epizodik gelecek düşüncesi arasındaki bağlantılara odaklanmaktadır. Dolayısıyla çalışmanın amaçlarından biri, çalışan belleğin görsel ve sözel bileşenlerinin epizodik gelecek düşüncesi üzerindeki rolünü karşılaştırmalı olarak incelemektir. Literatürde ne çalışan belleğin görsel bileşeninin gelecek düşüncesi üzerindeki rolüne odaklanan ne de görsel ve sözel bileşenleri karşılaştırmalı olarak inceleyen bir çalışma bulunduğundan, yapılan çalışma bir ilk niteliğindedir.

Epizodik gelecek düşüncesinin oluşumuna ilişkin ön plandaki kuramsal yaklaşım, Schacter ve Addis'in (2007) yapılandırıcı epizodik simülasyon hipotezidir. Bu yaklaşıma göre, gelecekle ilgili kurgular epizodik bellekten gelen bilgilerin yeniden yapılandırılması sayesinde oluşturulabilmektedir. İnsanların gelecek kurgusu oluştururken geçmişten gelen bilgileri kullandığı ve bu bilgileri yeniden bir araya getirerek zihinsel bir simülasyon oluşturduğu düşünülmektedir (Schacter vd.,2017). İnsanların geçmişi hatırlarken ve geleceği düşünürken olayları nasıl deneyimlediklerine ilişkin karşılaştırmalı çalışmalar da bu yaklaşımı destekler niteliktedir. Örneğin, amnezi hastaları sadece geçmişi hatırlamakta değil, geleceğe yönelik simülasyonlar oluşturmakta da güçlük çekmektedirler (Cole vd., 2016). Ayrıca ileri yaştaki katılımcıların, genç katılımcılara kıyasla hem geçmiş hem de gelecek düşüncelerinde olayın nerede, ne zaman olduğu/olacağı gibi epizodik detayları daha az ürettikleri gözlemlenmektedir (Schacter vd., 2013). Ayrıca pek çok çalışma epizodik belleğin ve gelecek düşüncelerinin altında yatan nöral bölgelerde örtüşmeler olduğunu ortaya koymaktadır (Bertossi vd., 2016; Berryhill vd., 2007; Race vd., 2013;

Spreng vd., 2009; Szpunar vd., 2007). Epizodik bellek ve epizodik gelecek düşüncesi arasında davranışsal ve nöral birtakım örtüşmelerin yanı sıra bazı ayrışımlar da gözlemlenmektedir. Gelecek kurgusu oluşturmanın geçmişe dair bir anı hatırlamaya kıyasla daha çok bilişsel efor gerektirdiği belirtilmekte (Anderson vd., 2012; El Haj ve Lenoble, 2018; Zavagnin vd., 2016; Rasmussen ve Berntsen, 2016) ve epizodik bellekle epizodik gelecek düşüncesi arasında birçok nöral ayrışma olduğu öne sürülmektedir (Addis, vd., 2007; Benoit ve Schacter, 2015; Bertossi vd., 2017; Coste vd., 2015). Epizodik bellek üzerinde çalışan belleğin görsel ve sözel bileşenlerinin rolünü ayrıştırmayı hedefleyen çalışma sayısı ise henüz çok kısıtlıdır. Yakın tarihli bir çalışmada hem görsel hem sözel bileşenlerin epizodik bellek süreçlerinde rolü olduğu ancak bileşenleri epizodik bellek performansını farklı zamanlarda ve farklı şekillerde etkilediği gözlemlenmiştir. Öte yandan, epizodik belleğin, ağırlıklı olarak görsel imgelemlere dayandığı ve geçmiş deneyimlerin temsil biçiminin genellikle görsel olduğunu ileri süren araştırmacılar da bulunmaktadır (Brewer, 1988; Conway, 2009; Rubin, Schrauf ve Greenberg, 2003; Rubin, 2005; 2006). Bu araştırmacıların ortaya koyduğu bulgular, epizodik bellek üzerinde çalışan belleğin görsel bileşeninin ağırlıklı rolünü vurgular niteliktedir. Bu bakımdan görsel ve sözel çalışan bellek bileşenlerinin epizodik bellek üzerindeki rolünün tekrarlı biçimde incelenmesi faydalı olacaktır. Bu noktada üzerinde durulması gereken önemli bir husus, epizodik belleğin bu farklı çalışmalarda nasıl ele alındığıdır. Örneğin, Plancher vd.'nin (2018) deneyindeki episodik bellek görevinde katılımcılardan sanal bir şehir turu yaparken çevrelerinde gördükleri nesnelerle ilgili bilgileri daha sonra hatırlamak üzere akıllarında tutmaları istenmiştir. Rubin ve meslektaşlarının çalışmalarında (2003) ise insanlardan geçmişte gerçekleşmiş bir olayı hatırlamaları istenir. Bu çalışmada katılımcılardan hem geçmişe hem de geleceğe yönelik bir olayı zihinlerinde canlandırmaları istenmiştir. Dolayısıyla bu çalışmada epizodik bellek olaysal bir bellek türü olarak ele alınmaktadır. Bu bilgiler ışığında, bu çalışmanın ikinci amacı, çalışan belleğin görsel ve sözel bileşenlerinin epizodik gelecek düşüncesi üzerindeki rolünü epizodik bellekteki rolüyle karşılaştırmalı olarak incelemektir. Bu sayede hem epizodik gelecek düşüncesi ve epizodik bellek arasındaki bağlantılar ilk kez çalışan bellek bileşenleri bağlamında incelenecek hem de epizodik bellekte görsel ve sözel bileşenlerin rolüne ilişkin önceki bulguların farklı bir yöntemle tekrar ele alınması mümkün olacaktır.

1.1. Epizodik Gelecek Düşüncesi Üzerinde Çalışan Belleğin Rolü

Epizodik gelecek düşüncesinin epizodik bellekte depolanan detayların bir araya getirilip yeniden yapılandırılmasıyla oluştuğu düşünülmekte ve bu süreçte bilginin kısa süreliğine zihinde tutulup manipüle edilmesi, yeniden düzenlenmesi gerekebilmektedir (Breeden ve ark. 2016). Geleceğe yönelik zihinsel canlandırmaların oluşturulması için bilginin bu şekilde tutulup işlenmesini sağlayabilecek yapının çalışan bellek olabileceği görüşü son 15 yılda yaygın biçimde destek bulmaktadır (Bahri ve Bahri, 2018; Ferretti vd., 2017; Hill ve Emery, 2013; Hill, 2017; Siddique vd., 2015; Suddendorf ve Corballis, 2007). Örneğin, Hill ve Emery (2013) tarafından yapılan çalışmada katılımcılardan çalışan bellek görevlerinin yanı sıra geçmişlerine ilişkin bir anı hatırlamaları ve geleceğe ilişkin bir olayı zihinlerinde canlandırmaları istenmiştir. Sonuç olarak, çalışan bellek kapasitesinin geleceğe yönelik spesifik canlandırmaları yordadığı gözlemlenmiştir (Hill ve Emery, 2013). Depresyon, anksiyete ve stres problemi olan ergenlerin olmayanlara kıyasla gösterdikleri zayıf gelecek düşüncesi performansını da yine çalışan belleğin yordadığı gösterilmiştir (Bahri ve Bahri, 2018). Bunlara ek olarak epizodik gelecek düşüncesindeki yaşa bağlı farklılıklarda da çalışan belleğin rol oynayabileceği düşünülmektedir. İleri yaştaki insanların genç insanlara kıyasla geleceğe yönelik simülasyonlar oluşturmakta ve bu olaylarla ilgili detayları üretmekte zorlandıkları tutarlı biçimde ortaya koyulan bir bulgudur (Addis vd., 2008, Addis vd., 2010, Gaesser vd., 2011). Genç ve ileri yaş katılımcılar arasındaki bu farklılıklara getirilen açıklamalardan biri, yaşlanmayla beraber zayıflayan çalışan bellek performansıdır (Zavagnin vd., 2016). Örneğin Zavagnin ve arkadaşları (2016) ileri yaştaki katılımcıların epizodik gelecek düşüncesi görevlerinde daha az detay üretmesinin bir sebebi olarak zayıf çalışan bellek ve ketleme performansını göstermektedir. Bir diğer çalışmada, ileri yaştaki insanların ürettikleri epizodik detaylar ve çalışan belleğin merkezi yönetici bileşeni arasında bir korelasyon olduğu ortaya koyulmuştur (Cole vd., 2013). Bulgular bir bütün halinde değerlendirildiğinde, çalışan belleğin epizodik gelecek düşüncesini destekleyen bir bilişsel süreç olabileceği düşünülmektedir. Bununla birlikte, bugüne kadar söz konusu bağlantıyı inceleyen çalışmaların büyük çoğunluğunda çalışan belleğin bir bütün olarak ele alındığı, çalışan belleğin bileşenleri (örn., merkezi yürütücü ya da epizodik tampon) düzeyinde ayrıma giden birkaç çalışma olduğu görülmektedir (Siddique vd., 2015; Ferretti vd., 2017). Mevcut çalışmalar, çalışan belleğin sözel bileşeninin 6-11 yaş arasındaki çocuklarda geleceği kurgulamayı destekleyebileceğini (Ferretti vd., 2017), epizodik tampon bileşeninin ise hem geçmişi hem de geleceği düşünmeye katkı sağlayabileceğini göstermiştir (Siddique vd., 2015). Buna rağmen söz konusu bağlantıyı inceleyen çalışmalarda çalışan belleğin bileşenleri henüz karşılaştırmalı olarak incelenmemiştir. Dolayısıyla günümüzde çalışan belleğin hangi bileşeninin epizodik gelecek düşüncesini nasıl desteklediği sorusu belirsizliğini korumaktadır. Yapılan çalışmanın altında yatan motivasyonlardan biri, literatürdeki bu boşluğu doldurmak, özellikle çalışan belleğin görsel ve sözel bileşenlerinin gelecek hakkında düşünebilme üzerindeki rolünü anlamaktır.

1.2. Epizodik Gelecek Düşüncesi Üzerinde Çalışan Bellek Bileşenlerinin Rolü

Çalışan belleğin epizodik gelecek düşüncesi üzerindeki rolünü inceleyen çalışmaların bir kısmı çalışan bellek performansını bir bütün olarak ele alırken, bir diğer kısmı da merkezi yürütücü, epizodik tampon ve fonolojik döngü bileşenlerine odaklanmıştır. Merkezi yürütücüye odaklanan çalışmaların temel çıkış noktasının epizodik gelecek düşüncesi görevlerinde gözlemlenen yaşa bağlı farklılıklar olduğu söylenebilir. Tipik olarak, genç katılımcılara kıyasla ileri yaştaki katılımcıların geleceğe yönelik imgelemler oluşturmakta ve olaylara ilişkin detaylar üretmekte zorlandıkları görülmektedir (Addis vd., 2008; Addis vd., 2010). Epizodik gelecek düşüncesindeki yaşa bağlı bu farklılıkların yaşlanmayla birlikte zayıflayan merkezi yürütücüyle ilgili işlevlere bağlı olabileceği düşünülmektedir (örn. Gaesser vd., 2011; Zavagnin vd., 2016). Örneğin, Zavagnin ve meslektaşları (2016) ileri yaştaki katılımcıların gelecek düşüncelerinde detay üretmekte zorlanmasının çalışan bellek ve özellikle de ketleme performansıyla ilişkili olduğunu bulmuşlardır. Bu bulgu, merkezi yöneticideki bireysel farklılıkların epizodik gelecek düşüncesini yordadığını gösteren diğer çalışmalarla da uyumludur (örn. D'Argembeau vd., 2010). Epizodik tampon bileşenine odaklanan araştırmacıların çıkış noktası ise yapılandırıcı epizodik simülasyon hipotezidir. Yapılandırıcı epizodik simülasyon hipotezi, gelecekte gerçekleşme olasılığı olan hipotetik olayların kurgusunun epizodik bellekten gelen bilgiler sayesinde gerçekleştiğini öne sürmektedir (Schacter ve Addis, 2007). Epizodik tampon bileşeni de epizodik bellekten gelen çeşitli bilgileri çalışan bellek sistemine dahil ettiği için (Baddeley, 2000), epizodik gelecek düşüncesi ve çalışan bellek bağlantısında epizodik tamponun rolü üzerinde durulmuştur (Schacter ve Addis, 2007). Örneğin, Siddique ve arkadaşları (2015) ikili görev prosedürü kullanarak bir epizodik tampon göreviyle eş zamanlı şekilde katılımcılardan geleceği ve geçmişi düşünmelerini istemişlerdir. Çalışmanın bulguları, epizodik tampon bileşeninin hem epizodik belleğe hem de epizodik gelecek düşüncesine katkı sağladığını göstermiştir.

Epizodik gelecek düşüncesinin altında yatan bilişsel faktörlere yönelik bir diğer çalışma ise 6 ile 11 yaş arasındaki çocukların sözel çalışan bellek performanslarıyla geleceği kurgulama performansları arasındaki ilişkiye odaklanmıştır (Ferretti vd., 2017). Çalışmada çocukların sözel çalışan bellek performansı arttıkça epizodik gelecek düşüncesi performansının da arttığı gözlemlenmiştir. Bu çalışmada üç ayrı görevle (ileri doğru sayı dizisi, geriye doğru sayı dizisi, anlamsız sözcük tekrarı) ölçülen sözel çalışan bellek puanlarının gelecek düşüncesi kurgulama performansındaki varyansın sadece %9.6'sını açıklaması ve sözel çalışan bellek görevlerinden birinin (anlamsız sözcük tekrarı) gelecek düşüncesi performansını yordaması dikkat çekicidir. Çocuklarda görsel çalışan bellek performansının da yaşla birlikte arttığını gösteren çeşitli çalışmalar hesaba katıldığında (örn. Burnett vd., 2012; Gathercole vd., 2004; Perlman vd., 2016; Simmering, 2012), sadece sözel çalışan bellek gelişiminin değil, görsel çalışan bellek gelişiminin de epizodik gelecek düşüncesi gelişimi üzerinde etkileri olabileceği düşünülebilir. Bulgular bir bütün olarak değerlendirildiğinde, çalışan belleğin epizodik gelecek düşüncesi üzerindeki rolünü daha iyi anlamak için farklı bileşenlerin karşılaştırmalı olarak ele alınması, özellikle de bugüne kadar hesaba katılmamış olan görsel çalışan belleğin gelecek düşüncesi üzerindeki rolünün incelenmesi gerekliliği ortaya çıkmaktadır.

1.3. Epizodik Gelecek Düşüncesi, Epizodik Bellek ve Görsel Bileşenin Potansiyel Rolü

Epizodik gelecek düşüncesini anlamaya yönelik araştırmalarda henüz çalışan belleğin görsel bileşeni üzerinde durulmaması literatürdeki önemli bir boşluğa işaret etmektedir. Halbuki epizodik gelecek düşüncesinin temelini oluşturduğu düşünülen epizodik belleğin ağırlıklı olarak görsel imgelemlere dayandığı ve geçmiş deneyimlerin temsil biçiminin genellikle görsel olduğu ileri sürülmektedir (Brewer, 1988; Conway, 2009; Rubin, Schrauf ve Greenberg, 2003; Rubin, 2005; 2006). Örneğin, Rubin ve meslektaşları (2003) bir anıdaki görsel imgelemler ne kadar canlıysa, geçmişteki belirli bir ana geri dönerek o anı tekrar yaşama hissini içeren epizodik hatırlamanın da o kadar güçlü olduğunu gözlemlemişlerdir. Bu ilişkisel bulguyu deneysel yöntemle test ettikleri bir diğer çalışmada ise bir grup katılımcı gözleri bağlı, diğer grup ise gözleri açık olarak laboratuvar ortamında bir olay (örn., bir tatil planlama süreci) deneyimlemişlerdir. Bir hafta sonra her iki grup da laboratuvara tekrar davet edilmiş ve ilk aşamadaki deneyimi hatırlamaları istenmiştir. Ardından bu deneyimle ilgili epizodik hatırlama derecelerini puanlamışlardır. Sonuç olarak, gözleri açık katılımcılara kıyasla gözleri bağlı katılımcıların hatırlama anı için daha düşük puanlar verdikleri bulunmuştur. Bu bulgu, deneyimdeki görsel bilgi kaldırıldığında epizodik hatırlama hissinin de azaldığı şeklinde yorumlanmaktadır (Rubin, Burt ve Fifield, 2003). Görsel imgelemlerin epizodik bellek üzerindeki rolüne işaret eden nöropsikolojik kanıtlar da bulunmaktadır. Bu çalışmalarda görsel imgelemler oluşturma becerisini bozan bir beyin hasarının genel bir epizodik bellek bozulmasına yol açabildiği gösterilmektedir (Conway, 1996; 2005; Rubin ve Greenberg, 1998). Örneğin, Rubin ve Greenberg (1998) görsel amnezi hastalarının görsel amneziden önceki anılarını hatırlayamadıklarını, görsel amneziden sonraki anılarını ufak tefek bozulmalarla hatırlayabildiklerini gözlemlemişlerdir. Hastalar, görsel amneziden önce görsel bilgiler eşliğinde kodladıkları anıları amneziden sonra hatırlamaya çalıştıklarında artık anıyla ilgili görsel imgelemler oluşturamayabilirler. Görsel imgelemler oluşturamamak anıya da erişememekle sonuçlanıyor olabilir. İkili-görev paradigması kullanarak yapılan daha güncel bir çalışma da görsel imgelemin epizodik bellekteki önemini göstermiştir (Gatti vd., 2022). Bu çalışmada katılımcılar 3 farklı koşulda (bilişsel yük yokken, görsel olmayan bilişsel yük varken, görsel bilişsel yük varken) otobiyografik bellek görevi gerçekleştirmişlerdir. Anının akla gelme süresinin (tepki süresi) bağımlı değişken olarak ele alındığı bu çalışmada görsel olmayan bilişsel yük bir etki göstermezken görsel bilişsel yük akla bir anı getirmeyi zorlaştırmıştır. Epizodik bellek üzerinde çalışan belleğin görsel ve sözel bileşenlerinin rolünü ayrıştırmayı hedefleyen bir başka çalışmada ise görsel ve çalışan bellek görevlerinin episodik bellek performansını farklı zamanlarda ve farklı şekillerde etkilediği ortaya konmuştur (Plancher vd., 2018). Bu çalışmada katılımcılardan sanal bir şehir turu yaparken çevrelerinde gördükleri nesneleri akılda tutmaları ve aynı anda ya sözel ya da görsel bir çalışan bellek görevi tamamlamaları istenmiştir. Sonuç olarak, eş zamanlı bir sözel çalışan bellek görevinin epizodik bellekte sadece nesnelerin kodlanmasını zorlaştırdığı, görsel çalışan bellek görevinin ise hem zamansal kodlamaya hem de bağlamın kurulmasına müdahale ettiği bulunmuştur.

Bugüne kadar görsel çalışan belleğin epizodik gelecek düşüncesindeki rolünü doğrudan inceleyen bir çalışma olmasa da beyindeki görsel ağın (visual network) epizodik gelecek düşüncesiyle büyük ölçüde ilişkili olduğu, hatta görsel sistemin epizodik gelecek düşüncesinin nöral altyapısını oluşturuyor olabileceği yönünde görüşler ileri sürülmektedir (Hu vd., 2023). Görsel ve uzamsal imgelemle gelecek düşüncesi arasındaki ilişkileri gösteren çalışmalar da görsel bilginin geleceğe yönelik canlandırmalarda önemli rol oynadığı görüşünü destekler niteliktedir (Aydın, 2018; de Vito vd., 2015). Bulgular bir bütün olarak, epizodik gelecek düşüncesinin altında yatan bilişsel mekanizmada görsel çalışan belleğin önemli rolü olabileceğini düşündürmektedir.

1.4. Çalışmanın amacı ve hipotezler

Bu çalışmanın ilk amacı, epizodik gelecek düşüncesi üzerinde sözel ve görsel çalışan belleğin olası etkilerini gruplar arası karşılaştırmalı olarak incelemektir. Bu amaçla, görsel veya sözel çalışan bellek gruplarına atanan katılımcıların bu görevlerle eş zamanlı bir şekilde epizodik gelecek düşüncesi görevi gerçekleştirecekleri bir ikili görev prosedürü kullanılmıştır. Çalışmanın ikinci amacı ise çalışan bellek bileşenlerinin epizodik gelecek düşüncesi ve epizodik belleği ayrı ayrı nasıl desteklediğini grup içi karşılaştırma yoluyla saptamaktır. Bu amaçlar doğrultusunda, çalışmada ikili görev paradigması kullanılarak görsel ve sözel çalışan bellek bileşenlerinin epizodik gelecek düşüncesi ve epizodik bellekle olan bağlantısı karşılaştırmalı olarak incelenmiştir. Epizodik gelecek düşüncesi ve epizodik bellek görevleri birincil görev olarak, görsel ve sözel çalışan bellek görevleri ise ikincil görev olarak düşünülmüştür. Katılımcıların yarısı görsel çalışan bellek görevi, diğer yarısı ise sözel çalışan bellek görevi yürütmüştür. Tüm katılımcılar ayrıca bir epizodik gelecek düşüncesi ve epizodik bellek görevi yürütmüşlerdir (tekli görev). Çalışmanın ikili görev aşamasında, tüm katılımcılar çalışan bellek görevlerini yürütürken aynı anda epizodik gelecek düşüncesi ve epizodik bellek görevleri de sürdürmüşlerdir. Çalışmanın sonunda görsel ve sözel çalışan bellek görevleriyle eş zamanlı yürütülen epizodik gelecek düşüncesi ve epizodik bellek görevlerinde düşüncelerin akla geldiği anda verilen tepki süresi ve bu düşüncelerin fenomenolojik özellikleri (örn., düşüncenin ne kadar canlı, detaylı ya da ne kadar olumlu/olumsuz duygu deneyimlendiği) hem gruplar arasında hem de grup içinde değerlendirilmiştir. İkili görev paradigmasında iki görev aynı bilgi işleme kaynağını kullanıyorsa bu görevlerde performansın düşmesi, farklı kaynaklar kullanıyorlarsa performansın iki görevde de aynı kalması beklenir. Örneğin epizodik gelecek düşüncesinin altında yatan mekanizma üzerinde görsel çalışan bellek sözel çalışan bellekten daha etkiliyse, ikili görevdeki sözel çalışan bellek koşuluna kıyasla görsel çalışan bellek koşulunda (a) gelecek düşüncesi tepki süresinin daha uzun/yavaş, (b) gelecek düşüncesinin özelliklerine yönelik fenomenolojik değerlendirmelerin daha düşük/zayıf olması beklenir. Tekli görev koşulunda gruplar arasında böyle bir fark beklenmemektedir. Benzer şekilde, eğer görsel çalışan bellek epizodik belleğe kıyasla epizodik gelecek düşüncesinde daha etkili ise (c) görsel çalışan bellek koşulunda epizodik gelecek düşüncesindeki tepki süresinin epizodik bellekteki tepki süresine kıyasla daha uzun/yavaş, (d) gelecek düşüncesinin özelliklerine yönelik fenomenolojik değerlendirmelerin epizodik belleğe kıyasla daha düşük/zayıf olması beklenir.

Bu doğrultuda test edilecek en temel iki hipotez şu şekildedir;

H1: Epizodik gelecek düşüncesi ve görsel çalışan bellek görevlerinin eş zamanlı yapılması, sözel çalışan bellek görevi yapmaya kıyasla, çalışan bellek kapasitesi kontrol edildikten sonra, daha yüksek tepki süresiyle (H1a) ve daha zayıf fenomenolojik değerlendirmelerle (H1b) sonuçlanacaktır.

H2: Epizodik gelecek düşüncesi ile eş zamanlı görsel çalışan bellek görevi yapmak, epizodik belleğe kıyasla, çalışan bellek kapasitesi kontrol edildikten sonra, daha yüksek tepki süresiyle (H2a) ve daha zayıf fenomenolojik değerlendirmelerle (H2b) sonuçlanacaktır.

2. Yöntem

Çalışmada çalışan bellek bileşenlerinin epizodik gelecek düşüncesi ve epizodik belleği nasıl desteklediği 2 (çalışan bellek bileşeni: görsel ve sözel) gruplar arası x 2 (temporal yön: epizodik gelecek düşüncesi, epizodik bellek) grup içi x 2 (görev türü: tekli görev, ikili görev) grup içi değişkenli karma desen kullanılarak saptanmaya çalışılmıştır. Bu doğrultuda görsel ve sözel şeklinde iki grup oluşturulmuştur. Bu gruplara rastgele atanan her katılımcı epizodik gelecek düşüncesi ve epizodik bellek görevleriyle eş zamanlı bir şekilde görsel ya da sözel çalışan bellek görevi yürütmüştür (ikili görev). Görevler eş zamanlı gerçekleştirilmeden önce her bir görev (çalışan bellek, epizodik gelecek düşüncesi ve epizodik bellek görevleri) tek başına gerçekleştirilmiştir (tekli görev). Ayrıca çalışmada merkezi yürütücü ve çalışan bellek kapasitesindeki bireysel farklılıkların kontrol edilebilmesi için İşlem Uzamı Görevi performansı ölçülmüştür. İşlem uzamı puanı ortak değişken (covariate) olarak analize dahil edilmiştir.

Bağımsız değişkenler: 2 (çalışan bellek bileşeni: görsel ve sözel) x 2 (temporal yön: epizodik gelecek düşüncesi, epizodik bellek) x 2 (görev türü: tekli görev, ikili görev)

Bağımlı değişkenler: tepki süresi (ms), fenomenoloji sorularına verilen cevaplar (1-7 likert)

2.1. Katılımcılar

Çalışmaya İstanbul Medipol Üniversitesi'nden anadili Türkçe olan ve normal veya düzeltilmiş normal görme yetisine sahip 193 lisans öğrencisi (171 kadın, 21 erkek, 1 belirtilmemiş; Ort = 21.4 yaş, SS = 2.09, ranj 18-29) ders kredisi karşılığında katılmıştır. Katılımcıların yaklaşık %68'i 6 saatten fazla uyuduklarını ve %71'i çalışmaya katılmadan önceki son öğünlerini 4 saat içinde yediklerini bildirmiştir. Katılımcıların %90,7'si sağ elini, %7,3'ü sol elini, %2,1'i ise iki elini kullanmaktadır. Dört katılımcı işlem süresi görevini tamamlayamamış ve analizden çıkarılmıştır. Tepki süresi analizleri için, katılımcıların boşluk tuşuna bastıktan sonra bir olayı rapor edemediği (38 vaka) ve düğmeye basmadan önce olayı rapor ettiği (8 vaka) denemeler analizden çıkarılmıştır. Buna ek olarak, tepki süresi analizi için aykırı değerler analizden çıkarılmıştır (15 vaka). Fenomenoloji analizleri içinse bir olay bildirmeyen toplam 38 katılımcının yanıtları hariç tutulmuştur.

2.2. Ölçüm Araçları

2.2.1. 2-Geri görevi. Çalışan belleğin sözel ve görsel bileşenlerinin epizodik gelecek düşüncesine katkılarını incelemek için 2-geri görevi kullanılmıştır. Kirchner (1958) tarafından tasarlanan n-geri paradigması genellikle çalışan belleğin kapasitesini değerlendirmek için kullanılmaktadır. Bu paradigmanın hem sözel versiyonu hem de görsel versiyonu bulunmaktadır (Jaeggi vd., 2010). Bu çalışmada kullanılan sözel ve görsel 2-geri görevleri Jaeggi ve meslektaşlarının (2010) çalışmasındaki görevlerden uyarlanmıştır. 2-geri paradigmasının sözel versiyonunda katılımcıya kulaklıkla birtakım harfler okunmakta, görsel versiyonunda ise katılımcılara bilgisayar ekranında farklı konumlarda beliren kareler gösterilmektedir (Jaeggi vd., 2010, Özbozdağlı vd., 2018). Katılımcının yapması gereken, 2 basamak öncesindeki şekil ya da harfin o an sunulan şekil ya da harfle aynı olup olmadığına hızlı ve doğru bir şekilde karar vermektir. Örnek vermek gerekirse, katılımcılardan her bir harfi duyduktan ya da her bir şekli gördükten sonra o anda ekranda bulunan harf ya da şeklin iki adım önce gösterilen uyaranla aynı olup olmadığına klavyedeki "H" tuşuna basarak karar vermeleri beklenmektedir. Örneğin katılımcı P K F **K** C R Z N **Z** Y Y harf dizisini birer birer duyarken kalın yazı tipiyle yazılmış harfleri duyduğunda "H" tuşuna basması gerekmekte, diğer harflerde ise herhangi bir tuşa basması gerekmemektedir. Aynı şekilde, o an gösterilen şeklin konumuyla 2 adım önce gösterilen şeklin konumu aynı ise "H" tuşuna basılması gerekmekte, değil ise herhangi bir tuşa basılması gerekmemektedir. Deney süresince her bir harf ya da şekil 500 ms (milisaniye) sunulmakta ve 2500 ms'lik bir aranın ardından diğer harf ya da şekil sunulmaktadır. Dolayısıyla katılımcının "H" tuşuna basabilmesi için her bir denemede azami 3000 ms vakti vardır.

2.2.2. Epizodik Gelecek Düşüncesi Görevi.

Epizodik gelecek düşüncesi görevi önceki çalışmalardan esinlenerek tasarlanmış (örn. D'Argembeau ve Mathy, 2011; D'Argembeau ve van der Linden, 2006) ve ikili görev paradigmasına uyarlanmıştır. Bu görevde katılımcılara başlangıç noktası sunma amacıyla bir ipucu sözcük gösterilmekte ve sunulan ipucu sözcüklerle ilgili ya da ilgisiz geleceğe yönelik bir olay düşünmeleri istenmektedir. Katılımcı ipucu sözcüğü gördükten sonra aklına bir olay gelir gelmez “BOŞLUK” tuşuna basıp aklına gelen olayı çok kısa bir şekilde, 2-3 sözcükle sesli bir şekilde ifade etmektedir. Bu sayede katılımcının gerçekten aklına bir olay gelip gelmediği saptanmakta ve tepki süresi (ms) ölçümü alınmaktadır. Katılımcı daha sonrasında aklına gelen bu olayı 30 saniye boyunca sessiz bir şekilde zihninde canlandırmaya çalışmalı ve süre bittikten sonra karşısına gelen fenomenolojik ölçüm sorularını yanıtlamalıdır (Addis vd., 2007; Janssen vd., 2021). İpucu sözcüğü gördükten sonra 15 saniye içinde “BOŞLUK” tuşuna basmayan katılımcılar gelecek düşüncesi oluşturamamış kabul edilmekte ve denemenin geriye kalan aşamaları atlanmaktadır. Bu süre, pilot çalışma sonucunda belirlenmiştir. Pilot çalışmadaki 8 katılımcıya epizodik gelecek düşüncesi yönergeleri verilerek ipucu sözcükler gösterilmiştir. Gelecek kurgusu oluşturma süreleri ölçülerek ortalama alınmış ve sonuç yukarı yuvarlanmıştır.

Yönergelerde, bu olayların önceden planlanmış ya da hayal ürünü olabileceği; önemli olanın, olayların gelecekte gerçekten gerçekleşebilecek makul olaylar olması gerektiği belirtilmektedir. Ayrıca bu olayların belirli bir yer ve zamanda geçen belirgin (spesifik) bir olay olması gerektiği de vurgulanmaktadır (örn. gelecek düşüncesi belirli bir yer ve zamanda gerçekleşmelidir, dolayısıyla 1 dakika ile birkaç saat arasında sürebilir ancak 1 tam günü geçmemelidir). Gelecek düşüncelerinin oluşumunu kolaylaştırmak için imgelenebilirlik (Min. = 6.44, Maks. = 6.87, *Ort.* = 6.64; *SS* = 0.15) ve somutluk (Min. = 6.64, Maks. = 6.96, *Ort.* = 6.85, *SS* = 0.10) değerleri birbirine yakın olan 12 somut ve nötr sözcük belirlenmiştir. Bu somut ve nötr sözcükler 800 sözcükten oluşan bir havuz içinden seçilmiştir (Kurdoğlu Ersoy ve Tekcan, 2018). Pratik aşamasında kullanılan sözcükler deney aşamasında kullanılmamıştır.

İpucu sözcüklerin ikili görev esnasında her iki grupta da aynı biçim ve zamanlamayla sunulabilmesi için uyaranlar arası süre içinde ekranın ortasında yazılı olarak gösterilmiştir. İpucu sözcük bilgisayar ekranının ortasında 1000 ms boyunca görünmektedir (Gatti vd., 2022). Bu sözcük siyah arkaplan üzerinde beyaz Arial 40 yazı karakteriyle gösterilmektedir. İpucu sözcük gösteriminin ardından katılımcının aklına bir olay geldiği an “BOŞLUK” tuşuna basması beklenmektedir. İpucu sözcüğün gösterildiği an ve “BOŞLUK” tuşuna basılması arasında geçen süre tepki süresi (ms) olarak kaydedilmektedir. Tepki süresi ölçümünün hemen ardından katılımcının karşısına 5 saniye süren beyaz bir ekran çıkmaktadır. Bu beyaz ekran katılımcının aklına gelen olayı çok kısaca, 2-3 sözcük kullanarak kısa bir şekilde sesli olarak özetleyeceği yerdir. Bu aşamada katılımcının verdiği cevap bilgisayar tarafından mikrofon aracılığıyla kaydedilmektedir. Eğer katılımcı aklına gelen olayı sözel bir şekilde raporlayamazsa gelecek düşüncesi oluşturamamış kabul edilmekte ve kaydedilen ölçümler veri setine kayıp veri olarak kodlanmaktadır. Bu yolla katılımcıların epizodik bellek ve gelecek görevlerini gerçekten yaptığına dair somut bir ölçüt oluşturulmuştur.

2.2.3. Epizodik Bellek Görevi

Epizodik bellek görevi önceki çalışmalardan esinlenerek tasarlanmış (örn. Addis vd., 2007; D'Argembeau ve van der Linden, 2006) ve ikili görev paradigmasına uyarlanmıştır. Bu görevin prosedürü verilen yönergeler hariç epizodik gelecek düşüncesi göreviyle birebir aynıdır. Bu görevde katılımcının sunulan ipucu kelimeyle ilgili ya da ilgisiz geçmişten bir anı çağırmaları istenmektedir. Katılımcılardan epizodik gelecek düşüncesi görevinde olduğu gibi belirgin bir olay hatırlamaları ve hatırladıkları olayın belirli bir yer ve zamanda, 1 dakika ile birkaç saat arasında sürebileceği ancak 1 tam günü geçmemesi gerektiği belirtilmektedir.

2.2.4. Fenomenolojik Karakteristiklerin Ölçümü

Katılımcılardan 30 saniye boyunca zihinlerinde sessiz bir şekilde detaylandırdıkları olayların canlılığı, görsel, uzamsal ve işitsel detayları, duygusal değerliği gibi özelliklerine yönelik sunulan 13 soruyu yanıtlamaları istenecektir (bkz. EK-4). Bu sorular literatürde sıklıkla kullanılan ve zihinsel zaman yolculuğunun fenomenolojik özelliklerini ölçmeyi hedefleyen sorulardır (D'Argembeau ve Linden, 2006; Akdere ve İkier, 2021; Özbek vd., 2017; Özbek vd., 2018). Her bir anket sorusu maksimum 20 saniye boyunca ekranda kalmaktadır. Katılımcılar anket sorularını klavyenin üst kısmında bulunan 1-7 tuşlarına basarak cevaplandırmaktadır.

2.2.5. İşlem Uzamı Görevi

Bu görev, merkezi yürütücü ve çalışan bellek kapasitesindeki bireysel farklılıkların kontrol edilebilmesi için katılımcıların çalışan bellek kapasitelerinin ölçülmesi amacıyla kullanılacaktır. Görevde, katılımcılardan bir dizi matematik sorusu çözmeleri ve bu soruları çözerken bir yandan sunulan harflerin sıralarını akıllarında tutmaları istenmektedir (Unsworth vd., 2005). Bu görevin çalışan bellek kapasitesini güvenilir ve geçerli bir şekilde ölçtüğü tekrarlı bulgularla gösterilmiştir (Redick vd., 2012; Unsworth vd., 2005).

2.2.6. Demografik Bilgi ve Strateji Değerlendirme Formu

Bu formla katılımcıların yaş ve cinsiyet bilgilerinin yanı sıra sağ/sol el kullanım bilgileri ve deney esnasında herhangi bir strateji kullanıp kullanmadıklarına ilişkin veriler elde edilecektir. Strateji soruları, katılımcıların 2-geri görevindeki uyaranları akılda tutarken bir sınıflandırma ya da kümeleme yapıp yapmadıklarını, epizodik gelecek düşüncesini ipucu sözcüğü görmeden önce kurgulayıp kurgulamadıklarını, anket sorularını yanıtlarken kurgulamaya devam edip etmediklerini, soruları yanıtlarken baştaki kurguyu değiştirip değiştirmediklerini deney sonunda tekrar kontrol etmeyi amaçlar.

2.2.7. İşlem

Araştırma, e-Prime 2.0 yazılımı ile uygulanmıştır. Görevler, Psikoloji Laboratuvarı'nda, bilgisayar karşısında tamamlanmıştır. Katılımcıların yarısı görsel yarısı ise sözel çalışan bellek grubuna rastgele atanmıştır. Sözel gruptaki katılımcılar harfleri kulaklık aracılığıyla duymuşlardır. Görsel gruptaki katılımcılar da kulaklık takacak ancak bir ses duymamışlardır. Tüm katılımcılar ilk önce bilgilendirilmiş onam formunu doldurmuştur. Ardından çalışma hakkında önce sözlü olarak bilgilendirilmiş, daha sonra yazılı yönergeler eşliğinde deneye başlamışlardır.

Katılımcılar her bir görev için bir pratik ve bir deney aşaması tamamlamıştır. Pratiği başarıyla tamamlanan görevin ardından asıl ölçümlerin alındığı deney aşamasına geçilmiştir. İlk olarak tekli görevlerin, daha sonrasında ise ikili görevlerin pratikleri yapılmıştır. Hem tekli hem de ikili görevlerde katılımcıların yarısı önce epizodik bellek, diğer yarısı ise önce epizodik gelecek görevini almıştır. Böylece geçmiş ve gelecek görevlerinin sırasından kaynaklanabilecek potansiyel etkiler dağıtılmıştır.

2.2.7.1. Tekli-görev işlemleri

Tekli-görev işlemi 2-geri görevinin pratik aşamasıyla başlamıştır. Katılımcıların bu görevi daha iyi anlayabilmesi için hem yazılı hem de görsel yönergeler kullanılmıştır. Görev yönergelerini tamamlayan katılımcılar 15 denemelik (4 hedef, 11 hedef olmayan) bir 2-geri setini tamamlamıştır. Bu pratik setinde %80 doğruluk oranına ulaşabilen katılımcılar sıradaki göreve geçmiş, ulaşamayan katılımcılar pratik setini tekrar etmiştir. Ardından asıl ölçümlerin alındığı 2-geri görevinin deney aşamasına geçilmiştir. Katılımcı, bu aşamada 20 denemelik bir 2-geri setini tamamlamıştır (5 hedef, 15 hedef olmayan).

2-geri pratiğini tamamlayan katılımcılar epizodik gelecek düşüncesi veya epizodik bellek görevinin pratik aşamasına geçmiştir. Pratik aşamasında katılımcıya yazılı bir yönerge verilmiş ve görevi anlayıp anlamadığı sorulmuştur. Görevi anlamayan katılımcılar sözel olarak tekrar bilgilendirilmiştir. Pratik aşaması başladığında ekranın ortasında bir fiksasyon noktası çıkmış, hemen ardından kısa bir süreliğine ipucu sözcük gösterilmiştir. Bu sözcük gösterildikten sonra fiksasyon noktası tekrar görünmüş ve katılımcının aklına bir anı/düşünce gelip "BOŞLUK" tuşuna basana kadar ekranda kalmıştır. Katılımcı tuşa bastıktan sonra aklına gelen olayı kısaca özetlemiştir. Bu özet mikrofon aracılığıyla E-prime tarafından kaydedilmiştir. Ardından bu olayı zihninde detaylandırması istenmiştir. Zihinde detaylandırma aşaması bittikten sonra ekrana fenomenoloji soruları gelmiştir. Fenomenoloji soruları yanıtlandıktan sonra asıl ölçümlerin alındığı deney aşamasına geçilmiştir. Deney aşamasındaki işlemler pratik aşamasındaki gibidir. Bu aşama tamamlandıktan sonraki görev, katılımcının diğer görev için (epizodik gelecek düşüncesi veya epizodik bellek görevi) pratik yapacağı kısımdır. Bu işlem, katılımcıya verilen yönerge hariç bir önceki işlemle birebir aynıdır. Böylece tekli-görev aşamaları tamamlanmış ve ikili-görev aşamalarına geçilmiştir.

2.2.7.2. İkili-görev işlemleri

Katılımcılar ikili-görev işlemi için ilk olarak ya epizodik bellek ya da epizodik gelecek düşüncesi ikili-görev pratiğini almışlardır. Bu görevde katılımcıların öğrendikleri iki farklı görevi aynı anda yapmaya çalışması beklenmiştir. Katılımcılar bu prosedüre ilk olarak 20 denemelik bir 2-geri göreviyle başlamıştır. Katılımcı 2-geri görevini sürdürürken belirli bir anda 2-geri görevi durmuş ve ekranın ortasında kısa süreliğine bir ipucu sözcük gösterilmiştir. İpucu sözcük gösteriminin ardından 2-geri görevi tekrar devam etmiştir. Bu aşamada katılımcı bir yandan bir olay hatırlamaya/kurgulamaya çalışırken bir yandan da 2-geri görevini sürdürmeye çalışmıştır. Katılımcının aklına bir olay geldiğinde "BOŞLUK" tuşuna basmış ve 2-geri görevi kısa bir süreliğine durmuştur. Bu aşamada katılımcı aklına gelen olayı birkaç kelime ile özetlemiştir. Ardından 2-geri görevi devam etmiştir. Katılımcıdan bu esnada olayı zihninde detaylandırmaya devam etmesi ve birazdan ekranda görünecek fenomenoloji sorularını yanıtlaması istenmiştir. Fenomenoloji soruları da yanıtlandıktan sonra pratik aşaması tamamlanmıştır. Deney prosedürü pratik prosedürü ile aynıdır.

İkili görevin ilk aşaması tamamlandıktan sonra katılımcı bir sonraki ikili görev aşaması (epizodik bellek ya da gelecek düşüncesi) için pratik yapmaya başlamıştır. Bu aşamadaki pratik ve deney işlemleri, katılımcıya verilen yönerge (epizodik bellek ya da gelecek düşüncesi) hariç bir önceki aşamayla birebir aynıdır. İkili görev deney aşamaları tamamlandıktan sonra katılımcılardan Demografik Bilgi ve Strateji Değerlendirme Formunu doldurmaları istenmiştir. Katılımcılar son olarak işlem uzamı görevini gerçekleştirmişlerdir.

3. Tartışma ve Sonuç

Bu çalışmanın amacı, çalışan belleğin görsel ve sözel bileşenlerinin epizodik gelecek düşüncesine farklı şekilde katkıda bulunup bulunmadığını ve çalışan bellek kapasitesinin etkilerini kontrol ederken bileşen kullanımının zamansal yönler arasında farklılık gösterip göstermediğini araştırmaktır. Bu amaçla, ikili görev paradigması kullanarak bir deney gerçekleştirilmiştir. Katılımcılardan geçmişteki kişisel bir olayı hatırlamaları ya da gelecekteki kişisel bir olayı zihinde canlandırmaları (birincil görevler) ve eş zamanlı bir şekilde görsel ya da sözel 2-geri görevlerini (ikincil görevler) yerine getirmeleri istenmiştir. İkili görevler sırasında hatırlanan/hayal edilen olayların fenomenolojik derecelendirmelerinin yanı sıra, 2-geri görevleri sırasında olayların akla gelme süreleri için tepki süreleri analiz edilmiştir.

Çalışmadan elde edilen bulgular beklentimizle örtüşerek geleceği kurgulamanın geçmişi hatırlamaktan daha uzun sürdüğünü ortaya koymuştur. Bu sonuçlar, geleceği düşünmenin daha fazla bilişsel kaynak gerektirdiğini ve geçmişi hatırlamaktan daha fazla ilişkisel işlem gerektirdiğini öne süren yapıcı epizodik simülasyon hipotezi ile uyumludur (Addis & Schacter, 2007). Elde edilen sonuçlar geleceğe yönelik bu düşüncelerin geçmişi hatırlamaya kıyasla daha az belirgin olduğunu, daha az önceden yaşıyormuş gibi hissedildiğini, ve uzamsal imgelemlerin daha az olduğunu göstermiştir. Ayrıca elde edilen sonuçlar geleceği kurgulamanın daha pozitif olarak algılandığını göstermiştir.

İlginç bir şekilde bilişsel yük altında geçmişi hatırlamak ve geleceği kurgulamak bilişsel yükün olmadığı duruma göre daha hızlı bir süreç olarak karşımıza çıkmıştır.

Bunun muhtemel bir sebebi olarak ikili görev pratik avantajı gösterilebilir (Strobach & Schubert, 2016; Strobach, 2020). Duyusal-motor bir görev içeren tekli görev ve pratik tekrarlarının ikili görev için avantaj oluşturmuş olabileceği düşünülmektedir. Ancak bu avantaj fenomenolojik bulgularda ortaya çıkmamıştır. Elde edilen bulgular bilişsel yükün olayların canlılığını, yeniden yaşıyormuş gibi hissetmeyi, görsel, işitsel, ve uzamsal imgelemi ve kişisel önemi azalttığını göstermekte, ayrıca olayların zihinde canlandırılmasını zorlaştırdığına işaret etmektedir.

Modaliteye özgü (görsel – sözel) bilişsel yük incelendiğinde elde edilen sonuçlar gelecek düşüncelerini oluşturmada her iki bileşenin de eşit katkı sağladığını ortaya koymuş, ancak görsel bileşenin sözel bileşene kıyasla geçmişten belirgin bir olay hatırlamayı daha çok desteklediğini göstermiştir. Öyle ki insanlar geçmişi hatırlarken görsel çalışan bellek yükünden dramatik bir şekilde etkilenmekte, sözel çalışan bellek yükünden ise geleceği kurgulamaya kıyasla önemli ölçüde etkilenmemektedir. Bu bulgu, görsel çalışan belleğin geçmişi hatırlamada önemli bir rol oynadığını ortaya koymaktadır.

Fenomenolojik ölçümler geleceği kurgulamanın sözel bileşene kıyasla görsel bileşenden daha çok yararlandığını ve bu tür düşüncelerin sözel çalışan bellek yükünden geçmişin hatırlanmasına kıyasla daha az etkilendiğini göstermiştir. Buna göre görsel çalışan bellek yükü gelecek düşüncelerinin duygusal yoğunluğunu ve kişisel önemini azaltmaktadır. Literatür kişisel önemin ve geleceğe yönelik zihinsel zaman yolculuğu hissinin çok yakından ilişkili olduğunu göstermekte (Lehner & D’argembeau, 2016; D’argembeau & van der Linden, 2012; Barsics vd., 2015), dolayısıyla görsel çalışan bellek yükünün geleceğe yönelik düşüncelerdeki bu hissi azalttığı düşünülmektedir.

Özetle sonuçlarımız görsel çalışan belleğin geleceği kurgulamayı ve geçmişi hatırlamayı farklı zamanlarda desteklediğini göstermektedir. Buna göre her iki bileşen de geleceği kurgulama aşamasında önemlidir, ancak görsel bileşen sözel bileşene kıyasla bu olayların detaylandırılma aşamasında daha önemlidir. Geçmiş olaylar için ise görsel çalışan bellek olayların oluşturulma aşamasında daha önemli bir rol oynamakta, ancak bu olayların detaylandırılma aşamasında her iki bileşenden de destek alındığı görülmektedir.

INTRODUCTION

People can construct mental simulations of possible and plausible future-oriented events, termed as episodic future thinking (Atance & O'Neill, 2001; Szpunar & Radvansky, 2016; Schacter et al., 2017). Studies showed that these simulations play a role in many cognitive, behavioral, and emotional processes ranging from constructing, planning, and monitoring goals (Demblon & D'Argembeau, 2014; D'Argembeau & Demblon, 2012) to health-related decision-making processes (Lawyer & Mahoney, 2018; Segovia et al., 2020; Stein et al., 2018), and self-regulation (Salgado & Berntsen, 2019). To understand the cognitive mechanisms underlying episodic future thinking, various factors such as the role of semantic information, emotional valence, and the structure and organization of thoughts have been examined (e.g., Schacter et al., 2013; D'argembeau & Van der Linden, 2004; Puig & Szpunar, 2017; D'argembeau & Demblon, 2012). However, studies investigating the role of working memory on future thinking are still quite limited. Working memory is a cognitive property that enables the storage, short-term retention, manipulation, and retrieval of information. Several models have been argued to explain the underlying mechanism of working memory (e.g., Cowan, 1988; Baddeley & Hitch, 1974; Oberauer, 2002). For instance, embedded memory models (e.g., Cowan, 1988; Oberauer, 2002; Cowan, et al., 2021), which treat working memory as the activated part of the information embedded in long-term memory, focus mainly on the interaction between working memory and long-term memory. Although the multi-component model of working memory has approached this holistic perspective in recent years (see Baddeley, 2000), they argue that memory is not a monolithic system. Instead, it consists of interrelated but independent components that process different types of information, such as visual and verbal (e.g., Baddeley & Hitch, 1974; Baddeley, 2000). Thus, the multi-component model is often utilized to investigate the modality-specific characteristics of information. According to this approach, the phonological loop component allows auditory and verbal information to be held and manipulated in the mind. The visuo-spatial sketchpad, on the other hand, allows the color, shape, size, or position of an object to be held and manipulated in the mind. The other two components are the episodic buffer and central executive components. The central executive coordinates the components of working memory by directing attention, while the episodic buffer is considered a temporary storage where information from the other components is collected and combined. This model allows researchers to study the role of these components in various cognitive processes (e.g., episodic memory; Plancher et al., 2018; mind wandering; Choi et al., 2017; problem-solving; Raghubar et al., 2010; comprehension; Woolley, 2010). In this context, the present thesis investigates the role of visual and verbal components of working memory in episodic future thinking by adopting a multi-component approach.

The main theoretical framework for the formation of episodic future thinking is the constructive episodic simulation hypothesis. Accordingly, future events can be generated by reconstructing information from episodic memory, which incorporates personal life experiences and allows individuals to remember past events (Schacter et al., 2017; Schacter & Addis, 2007). Comparative studies of how individuals experience events when imagining the future and remembering the past support this approach. For example, patients with amnesia have problems not only with episodic memory but also with episodic future thinking (Cole et al., 2016). Moreover, older participants produce fewer episodic details, such as the location and timing of events, in both future and past thoughts compared to younger participants (Schacter et al., 2013). The underlying neural activations in episodic memory and episodic future thinking also largely overlap in the brain. Studies point to the medial temporal lobe as a prominent brain area for both episodic memory and episodic future thinking (Race et al., 2011; Bertossi et al., 2016; Szpunar et al., 2007). These studies suggest that episodic memory and episodic future thinking share some common features.

In addition to some behavioral and neural overlap between episodic memory and future thinking, there are also some divergences. For example, studies show that episodic future thinking may be more cognitively demanding than episodic memory (Anderson et al., 2012; Wiebels et al., 2020; Zavagnin et al., 2016; Arnold et al., 2011; El Haj & Lenoble, 2018). This assumption is logical because constructing future events can involve various combinations of information stored in episodic memory while remembering past events often entails searching for specific combinations of information. Therefore, thinking about the future may require effortful inhibition of a wide range of unnecessary information to create novel and plausible events (Anderson et al., 2012). The constructive episodic simulation hypothesis suggests that episodic future thinking involves more cognitively demanding relational processing than episodic memory, as it requires the formation of new relations. This demand may not be as high as in the past, where the relations already exist (Roberts et al., 2016). This assumption is supported by phenomenological findings, showing that imagining the future results in poorer sensory details compared to remembering the past (Arnold et al., 2011; D'Argembeau & Van der Linden, 2004). Episodic future thinking differs from episodic memory in being more goal-oriented, less vivid, more positively valenced, and often imagined from a third-person rather than a first-person perspective (Hallford et al., 2018; D'Argembeau & Van der Linden, 2004; 2006; Salgado & Berntsen, 2019; D'Argembeau et al., 2010). Moreover, these temporal directions exhibit different eye movement patterns, likely due to differences in the cognitive demands of future thinking (El Haj & Lenoble, 2018; El Haj & Moustafa, 2020). The neuroimaging studies also point to some dissociations between episodic memory and episodic future thinking (Addis et al., 2007; Benoit & Schacter, 2015; Szpunar et al., 2007). The neural activity involved in episodic future thinking is much greater than in episodic memory (Szpunar et al., 2007; Addis et al., 2007). Consequently, these studies have found some similarities and differences in comparing the past and the future, but these temporal directions have not been compared in terms of working memory components.

Furthermore, there is still very little research that attempts to distinguish the role of visual and verbal working memory on episodic memory. In a recent study, Plancher et al. (2018) showed that although both visual and verbal components are involved in episodic memory processes, they have different effects on episodic memory performance at different times. In addition, some researchers argue that episodic memory is predominantly based on visual imagery and that the representation of past experiences is generally visual (Brewer, 1988; Conway, 2009; Rubin et al., 2003; Rubin, 2005; 2006). The studies of these researchers emphasize the predominant role of visual working memory in episodic memory. An important point to be emphasized at this point is how episodic memory is treated in these different studies. For example, on the one hand, in the episodic memory task in Plancher et al.'s (2018) experiment, participants were instructed to keep the information about the objects they saw around them in mind for later recall while taking a virtual city tour. However, in Rubin et al.'s (2003) investigation, people were asked to recall a specific event that took place in the past. The latter involves imagining a chain of events that occurred in a specific time and place in one's past and requires mental time travel. People can also simulate the future in the same way by imagining their upcoming events (Szpunar et al., 2014). Therefore, we operationalized episodic memory as the recollection of a specific personal event that occurred in the past, and episodic future thinking as the imagination of a specific personal event that might occur in the future. Given these points, the second aim of the study is to examine the roles of visual and verbal working memory in episodic future thinking compared to their roles in episodic memory. In this respect, it would also be beneficial to repeatedly examine the role of visual and verbal working memory components on episodic memory.

In line with these aims, the roles of visual and verbal working memory components to episodic memory and episodic future thinking were examined comparatively using a dual-task paradigm. episodic memory and future thinking tasks were considered primary tasks, while visual and verbal working memory tasks were considered as secondary tasks. In the single-task phase, half of the participants completed a verbal working memory task, while the other half completed a visual working memory task. Participants also performed a past remembering and an episodic future thinking task. During dual-tasking, participants carried out episodic future thinking and episodic memory tasks concurrently with the attended working memory tasks, either visual or verbal. In episodic future thinking and episodic memory tasks conducted simultaneously with working memory tasks, we compared the duration of thought formation and the phenomenological characteristics of these thoughts - such as their vividness, sensory details, and positive/negative emotions experienced - both between and within groups. In dual-task paradigms, when two tasks share the same information processing resource, performance is anticipated to decline in those tasks (Fisk et al., 1986; Logie & Duff, 2007; Duff & Logie, 1999; 2001; Cocchini et al., 2002; Doherty & Logie, 2016). Conversely, if they utilize different resources, performance is expected to remain relatively unchanged in both tasks. In this study, we have taken this assumption as a basis for understanding the underlying cognitive mechanisms of episodic future thinking and have further revealed its similarities and differences with episodic memory in terms of the working memory component's usage.

In the following sections, theoretical views explaining the role of working memory in mental time travel will be discussed. In this part, we will explore why working memory is a suitable candidate for the mental time travel workspace and how working memory may contribute to these journeys. Subsequently, we will review these contributions within two temporal domains: episodic future thinking and episodic memory. This review will discuss whether working memory plays a differential role within these temporal directions. Following this, we will delve into working memory components and explain how they contribute differently to these temporal directions. In these sections, we will begin by addressing episodic memory and then proceed to episodic future thinking.

CHAPTER I

1. Working Memory and Mental Time Travel

Being able to disengage from the present time by shifting mentally backward through the past and forward through the future refers to mental time traveling (Tulving, 2002; Suddendorf & Corballis, 2007). People often travel through both temporal directions by thinking about the events that occurred in the past or events that might happen in the future. Episodic future thinking and episodic memory mechanisms can be considered as two poles of mental time travel. These two mechanisms are also thought to be fundamental in developing the phenomenological representation of a perpetual self-concept through space and time, known as autonoetic consciousness which is crucial to performing mental time travel (Tulving, 1985). This type of consciousness allows people to be aware of themselves when remembering the past and imagining future events (Tulving, 2002). Therefore, these are not the events experienced or narrated by someone else, but rather personal, self-relevant events. The neural commonalities between the future and the past could explain this autonoetic consciousness phenomenon. For example, in a study, participants were instructed to retrieve specific personal past and future events with the help of event cues. In addition to self-relevant events, participants also thought about event-cue-related scenarios about Bill Clinton (e.g. “I saw Bill Clinton at a meeting in Pentagon, alongside faceless generals and soldiers”). Interestingly, the neural overlaps have been observed to a lesser extent when participants imagine Bill Clinton; however, there was a notable overlap between personal past and future events (Szpunar et al., 2007). The results suggest that self-referential processing co-occurs during mental time travel. This interpretation can also be supported by another study, which showed the importance of general personal knowledge in episodic future thinking (D’argembeau & Mathy, 2011). The study investigated the construction phase of episodic future thinking and how those thoughts are organized in knowledge structures by conducting 3 separate studies. The findings showed that participants first utilize general personal knowledge when envisioning the future or remembering the past, followed by general events and then specific events. Therefore, mental time travel ability prerequisites an autonoetic consciousness that draws upon various knowledge organizations to be reconstructed.

Mental time travel also requires a mental platform where personal experiences and semantic knowledge are integrated to create mental simulations of the future and the past. Working memory is well-suited for this mental platform, given its effectiveness in information processing, including temporary storage and information manipulation (Dere et al., 2019; Breeden et al., 2016; Suddendorf & Corballis, 2007). The working memory system not only provides information manipulation for contextual information (verbal, visual, spatial, olfactory, etc.) in its components (e.g. phonological loop, episodic buffer, visuo-spatial sketchpad) but also enables the integration of information from these diverse categories into an event via the central executive component (Breeden et al., 2016). Thus, Breeden and his colleagues (2016) propose a new component to the multi-component model of working memory, the MTT platform, that operates as an experience reconstruction system. Their model suggests that a higher complexity of the "MTT platform" corresponds to an elevated level of autonoetic consciousness in certain species. It is also claimed that the evolution of processing power and working memory should be linked to the evolution of mental time travel, therefore; sufficient working memory capacity is crucial for mental time travel (Breeden et al., 2016; Dere et al., 2019).

Marchetti (2014) argues that mental time travel is a constructive process that requires retaining and manipulating information over a short period, thus utilizing working memory. According to his theory, attention and working memory mechanisms are the two fundamental mechanisms for constructive processes that underpin mental time travel. Therefore, to simulate oneself in the future or past, internal attention is required to be directed towards either temporal direction, with working memory aiding in organizing the events within a temporal coordinate system. This view may align with the foreground hypothesis of mental time travel, known as constructive episodic simulation, which posits that imagining the future and remembering the past involves a flexible reconstruction of episodic details from the past to generate new scenarios through forming new relations (Schacter & Addis, 2007). These relational processes allow people to create specific scenarios of the past and the future by binding the objects and spatial features as well as integrating the other details such as people, places, emotions, actions, etc. (Roberts et al., 2016). However, it is most likely that the relational process demands are not equal between the temporal directions. For instance, envisioning the future involves simulating a series of actions that have not yet occurred. Therefore, one needs to predict these actions to create specific future events, more so than remembering the past, as the actions have already been represented in the brain to some extent (Szpunar et al., 2007). Interestingly, Szpunar and his colleagues (2007) demonstrated increased brain activity in networks associated with spatial working memory and attention during episodic future thinking as compared to past remembering. There is also enough evidence that episodic future thinking is a more cognitively demanding process than episodic memory process (Hill & Emery 2013; Anderson & Dewhurst 2009; Wiebels et al., 2020; El Haj & Moustafa 2020; D'argembeau et al., 2010; McDonough & Gallo 2010; D'argembeau & Mathy 2011; Richmond & Pan; 2013) episodic future thinking, hence, may involve a more cognitively demanding relational process than episodic memory (Roberts et al., 2016). Given the relational demand of episodic future thinking, and the findings showing the differences between episodic future thinking and episodic memory in various domains (on a phenomenological level; Arnold et al., 2011; D'Argembeau & Van der Linden, 2004; on a physiological level; de Vito et al., 2015, El Haj & Moustafa, 2020; El Haj & Lenoble, 2018; and on a neural level; Addis, et al., 2007; Coste et al., 2015; Benoit

& Schacter, 2015), working memory utilization would also likely be different between the temporal directions.

1.2. Episodic Memory and Working Memory

Episodic memory is a hypothetical memory system that represents specific mental experiences, including information about time, space, and perceptual details (Tulving, 2002). Many studies investigating the role of working memory on episodic memory have shown a connection between retrieving specific memories and working memory (Kemps & Tiggemann, 2007; Ros et al., 2010; Daselaar et al., 2008; Guler et al., 2018; Maxfield et al., 2008). For example, individuals who have difficulties maintaining and updating information in working memory tend to retrieve more over-general memories (non-specific events) compared to those with higher working memory capacity (Ros et al., 2010). In this study, a group of older and young adults were compared on autobiographical memory performance, and the association between different working memory tasks (reading span and working memory with sustained attention load) and over-general memories was evaluated. The study findings revealed that older adults tend to recall more generalized memories and various measures of working memory were positively correlated with the increasing number of remembering specific events. The connection between memory specificity and working memory might explain why older adults recall fewer specific memories compared to younger individuals, given that working memory performance tends to decline with aging. Indeed, updating (measured with n-back) and inhibition (measured with Stroop) performances, which are considered functions of working memory, mediated the relationship between memory specificity and aging (Piolino et al., 2010). Similarly, in another study, inhibitory control and cognitive flexibility were found to be related to retrieving more specific memories (Guler et al., 2018). In this study, participants were presented with concrete and abstract cue words and asked to recall a specific memory, and their executive function performance was tested on different subcomponents (inhibition control, information monitoring/updating, shifting). The results pointed out that attentional resources and inhibitory control mechanisms have a pivotal role in retrieving specific memories. Additionally, semantic-autobiographical remembering may also be related to working memory. For instance, Unsworth and his colleagues (2012) had their participants recall their Facebook friends on different levels (number of remembered friends, speed of name recall, number of friend clusters, and the size of the clusters) and measured the working memory capacity with three different tasks: operation, symmetry and reading spans. The study revealed that the participants who had greater working memory capacity remembered more names and did so at a faster rate than those who had lower working memory capacity. The reason behind the relationship between working memory and episodic memory may stem from the relational processing as proposed by the constructive episodic simulation hypothesis. For instance, Unsworth and his colleagues (2011) used the encoding specificity principle to investigate the importance of this effect on the relationship between working memory and episodic memory. The encoding specificity principle suggests that the ability to remember an event relies on how well the features of the event match with the features of the retrieval cue (Tulving & Thomson, 1973). Interestingly, individuals with higher working memory capacity outperformed those with lower capacity when the conditions for encoding and retrieval match. However, in a situation where there was a mismatch between these conditions, those with higher working memory capacity were more adversely affected compared to individuals who had lower working memory capacity. Therefore, people may utilize working memory for relational processing, allowing them to establish connections between different pieces of information and integrate them into coherent memory representations.

1.3. Episodic Future Thinking and Working Memory

The view that working memory could enable the retention and manipulation of information for the formation of episodic future thinking has gained support in the last 15 years (Suddendorf & Corballis, 2007; Addis et al., 2008; D'argembeau et al., 2010; Hill & Emery, 2013; Breeden et al., 2016; Zavagnin et al., 2016; Ferretti et al., 2017; Bahri & Bahri, 2018). For example, in a study by Hill and Emery (2013), participants completed several working memory measures in addition to autobiographical tasks which included fluency, specificity, and episodic details of future and past events. The findings demonstrated that working memory capacity promotes the formation of specific future-oriented events but does not significantly contribute to remembering specific past events to the same extent. It has also been shown that working memory predicts the impaired future thinking performance of adolescents with depression, anxiety, or stress problems compared to those without such issues (Bahri and Bahri, 2018). This study compared the future thinking characteristics, including fluency, specificity, and episodic details, as well as working memory's role, between adolescents experiencing internalizing issues and those who are non-clinical. The comparison showed significant differences in terms of future specificity and episodic details and further revealed a positive correlation between overall future thinking score and working memory capacity. Overall, the findings indicate that working memory capacity could contribute to episodic future thinking.

Working memory also plays an important role in age-related differences in episodic future thinking. Older people have difficulty in creating future-oriented simulations and producing details about these events compared to younger people (Addis et al., 2008, Zavagnin et al., 2016; Addis et al., 2010; Cole et al., 2013; Gaesser et al., 2011). One of the explanations for these divergences between older and younger participants is the decline in working memory performance with aging (Zavagnin et al., 2016). For instance, Zavagnin et al. (2016) claimed that impaired working memory and inhibition performance are some of the reasons why older participants produce fewer details in episodic future thinking tasks. Consistent with this assumption, the internal details of future thoughts were found to correlate with the digit backward span score, which is considered a measure of executive functioning (Addis et al., 2008). Another work also indicated a positive correlation between the episodic details produced by older people and executive functions, suggesting that executive processes underpin episodic future thinking (Cole et al., 2013). This study further argues that thinking about the future involves multimodal information processing within working memory to create a novel, coherent event. The results of these studies align with D'Argembeau and his colleagues' (2010) work, which showed a connection between executive processes and episodic future thinking, and cognitive properties associated with these processes. In this study, participants completed various measures of episodic future thought and autobiographical memory regarding phenomenology, fluency, specificity, and episodic details. Additionally, the participants also completed a wide range of neuropsychological measures that play a role in episodic future thinking including relational memory processing, executive functioning, time perspective, autonoetic consciousness, and visuospatial processing. The study found that measures of executive processes were predictive of both future and past events, but executive functioning was particularly related to future thinking, especially when the event was specific.

Another line of studies shed light on the importance of working memory in episodic future thinking through applied research that investigates decision-making processes. In recent years, an increasing number of studies has shown that episodic future thinking is one of the strategies that can support decision-making processes by reducing the distance between the present and the future in our minds and strengthening our connection with the future (Daniel et al., 2013; Schacter et al., 2017; Szpunar & Radvansky, 2016; Daniel et al., 2015). For example, episodic future thinking increases the tendency to make decisions that are beneficial for health, including quitting smoking (Stein et al., 2018; Chiou & Wu, 2017), eating habits (Daniel et al., 2013; Daniel et al., 2015; Dassen et al., 2016; Segovia et al., 2020), or continuing/leaving a hobby that may have positive/negative effects on health (Kaplan et al., 2016). Some studies suggest that working memory training can facilitate the efficiency of episodic future thinking in decision-making processes, such as delay discounting. In a study examining the effects of working memory training on delay discounting in stimulant addict individuals, it was found that the training has a significant impact on reducing delay discounting compared to the control group (Bickel et al., 2011). Nevertheless, that enhancement may have been influenced by episodic future thinking since Snider et al. (2018) demonstrated the pivotal role of episodic future thinking in the connection between working memory and delay discounting. In this study, individuals with alcohol dependence completed three types of tasks before and after the working memory training: a near-transfer novel working memory task, delay discounting alone and delay discounting combined with episodic future thinking. As expected, the training improved the performance on the near-transfer novel working memory task. More importantly, a rate-dependent decrease in delay discounting was observed following the training, particularly in individuals with the highest baseline rates of delay discounting combined with the scores of episodic future thinking. That is, working memory training enhanced the effectiveness of episodic future thinking in reducing delay discounting. In a similar study that investigated the role of episodic future thinking in delay discounting, it was also demonstrated that Backwards Corsi and Digit Span task scores, which are considered working memory measures, moderated the effectiveness of episodic future thinking on the rate of delay discounting (Bickel et al., 2020). Consequently, these studies support the view that working memory is a cognitive property that facilitates episodic future thinking.

Overall, the literature suggests that future thinking relies more on relational processing and is more cognitively demanding than past remembering. Both episodic future thinking and episodic memory appear to benefit from working memory in various ways, but the role of working memory in these cognitive processes remains poorly understood. The multi-component model of working memory is a memory model that processes different types of information, consisting of independent components that are interconnected (Baddeley & Hitch, 1974; Baddeley, 2000). Many studies examining the role of working memory addressed this cognitive process in a unitary manner, with only a few studies distinguishing between its components. Hence, it remains unclear whether various components of working memory contribute differently and if the disparity between future thinking and past remembering arises from this distinct utilization.

1.4. Contributions of Working Memory Components to Episodic Memory and Episodic Future Thinking

There has been relatively more focus on investigating the connection between working memory components and episodic memory than on future thinking. At first glance, the episodic buffer component seems to be more concerned with episodic memory, as it serves a feature-binding function and may be utilized to create representations of past events. Baddeley's (2000) episodic buffer component and Tulving's (2002) episodic memory concept share similarities in integrating space and time and feature binding, yet they diverge concerning time: the episodic buffer functions as a temporary storage, whereas episodic memory is often associated with episodic long-term memory. Piolino and her colleagues (2010) demonstrated that age-related declines in remembering the past are primarily influenced by impairments in updating and inhibition functions (executive functions) with a lesser impact observed in the feature binding (episodic buffer). In line with these results, overall, the literature suggests that the central executive component plays a pivotal role in episodic recollections (Unsworth et al., 2012; Piolino et al., 2010; Daselaar et al., 2008; Ros et al., 2010). While the studies may not explicitly mention the "central executive" component, the term "executive functions" or “working memory capacity” could serve as an indicator of the central executive component's role, given their shared emphasis on similar cognitive mechanisms (McCabe et al., 2010). The other components of working memory, visuospatial sketchpad, and phonological loop, may also differ from each other in terms of information encoding. For example, the phonological loop is associated with encoding objects, while the visuospatial sketchpad is linked to contextualization and temporal encoding (Plancher et al., 2018). The studies also suggest that visual imagery is crucial for episodic memories, hence the utilization of visual information might tax visuo-spatial sketchpad (Rubin et al., 2003; Gatti et al., 2023; Anderson et al., 2017; Sheldon et al., 2019; Anthony et al., 2023). However, additional research is needed to comprehend the role of working memory components in episodic memories and to delineate how they differ from future thinking in terms of component utilization.

The limited number of studies investigating working memory components and episodic future thinking has shown that the verbal component of working memory can support the construction of the future in children aged 6-11 years (Ferretti et al., 2017), and the episodic buffer component can contribute to both past and future thinking (Siddique et al., 2015). Another line of studies focused on the central executive component, claiming that age-related differences in future thinking can be explained by the decline of working memory and inhibition performance (Zavagnin et al., 2016; Gaesser et al., 2011). The other findings support this interpretation, suggesting that executive functions are important determinants of creating specific future-oriented thoughts (D’argembeau et al., 2010; Hill & Emery, 2013). In these studies, similar to those investigating episodic memory, the central executive component was not mentioned. Instead, the focus has been on executive functions or working memory capacity. However, these results may highlight the role of the central executive component for similar reasons as interpreted in studies on episodic memory. Interestingly, little effort has been put into exploring the role of visuo-spatial working memory as in episodic memory. Considering the dominance of visual information in episodic memory (Brewer, 1988; Conway, 2009; Rubin, Schrauf & Greenberg, 2003; Rubin, 2005; 2006), and the constructive episodic simulation hypothesis which handles episodic memory as the source of future thoughts, it is necessary to investigate the role of the visuospatial component on future thinking.

1.4.1. Central Executive

The central executive component serves as a director of executive attention and indicator of working memory capacity. It coordinates the other components of working memory by directing the source of attention (Baddeley, 2000; Baddeley & Hitch, 1974), and is sometimes referred to as executive functioning, depending on the study area. For instance, while neuropsychologists usually use the term "executive functioning" to refer to attentional control, experimental psychologists typically employ the term "working memory capacity", which indicates the effectiveness of the central executive component, to refer to the same cognitive property (McCabe et al., 2010). Studies investigating episodic memory and working memory often use the terms "executive functioning" or "executive processing", which thus imply the involvement of the central executive. These studies have delved into executive processes and investigated information maintaining, updating, inhibition, etc. separately. For instance, research has shown that information maintenance and updating abilities predict an individual's capacity to retrieve specific episodic memories (Ros et al., 2010), while updating and inhibition abilities mediate the connection between memory specificity and aging (Piolino et al., 2010). Furthermore, working memory capacity, measured by operation, symmetry, and reading span tasks, predicts episodic memory performance (Unsworth et al., 2012). Therefore, the studies mentioned above, demonstrating the contributions of working memory capacity and executive processes to episodic memory, highlight the role of the central executive component in episodic memory.

The role of the central executive in episodic future thinking has been relatively less studied than in episodic future thinking, possibly due to the popularity of episodic memory. Similar to episodic memory, the aforementioned studies that consider working memory as one of the underlying factors of future thinking support the facilitatory role of the central executive in episodic future thinking. For example, D'argembeau et al. (2010) showed that both future thinking and past remembering utilize executive processes, but specific future events were more associated with these processes. Similarly, Hill and Emery (2013) showed that working memory capacity is positively correlated to specific future events, but lesser extent to past events. Ultimately, the central executive appears to be a crucial mechanism for mental time travel, but it is likely to be more important for future thoughts, as they require the creation of new relations to construct novel events.

1.4.2. Episodic Buffer

The episodic buffer component is responsible for information integration in cooperation with the slave components to fulfill the orders of the central executive. Conway (2003) has suggested that reminiscence of past events would comprise recordings of representations formed by episodic buffer, which can bind information from different sources into cohesive episodes that can be consciously accessed. Piolino and her colleagues (2010) conducted a study to find out how episodic buffer and central executive components contribute to episodic recollections sampling younger and older adults. They used a verbal autobiographical fluency task and categorized memories into different specificity levels and employed working memory tasks that measure feature binding, inhibition, updating, and shifting. The findings revealed that the decline in memory specificity associated with aging was mediated by the central executive (updating and inhibition) and to a lesser extent by the episodic buffer. Therefore, the involvement of episodic buffer in the recollection of specific past events may be limited to the efficiency of the central executive.

Since the episodic buffer component incorporates various information from episodic memory into the working memory system (Baddeley, 2000), it was suggested that the connection between future thinking and working memory may rely on the episodic buffer (Schacter & Addis, 2007; Suddendorf & Corballis, 2007). The feature-binding function of the episodic buffer makes it a suitable stage for creating future-oriented simulations (Schacter & Addis, 2007). In a dual-task study testing this assumption, participants performed an episodic buffer task while concurrently performing past remembering and future thinking tasks (Siddique et al., 2015). The participants attempted to remember past or imagined future events while concurrently engaging in a verbal-spatial binding task, which was expected to activate the episodic buffer. The results of the study revealed that the episodic buffer component contributed equally to episodic memory and future thinking, thus episodic buffer did not differ for the two temporal directions.

1.4.3. Phonological Loop

The phonological loop component is concerned with the processing of auditory input (e.g., voices, sounds, language processing). Studies investigating the phonological loop in the context of episodic memory have addressed this component in comparison with the visuospatial sketchpad. For example, Janssen and his colleagues (2015) probed how different cognitive abilities contribute to autobiographical memory differently. They employed a total of fourteen tasks to measure visual and verbal memory (digit span task, Corsi block tapping task, DRM delayed recognition task, etc.), accounting for either working memory or episodic memory abilities. When these tasks' scores were z-transformed and entered hierarchical regression analysis together, they significantly predicted episodic memory performance, albeit with a weak effect size and a p-value of .04. After entering verbal and visual memory scores separately, only verbal memory showed a significant effect on episodic memory performance. Although the authors did not explicitly address working memory and the effect size was minor, their findings imply a potential significance of the phonological component in episodic memory. In a more ecological setting, another study aimed to differentiate the contributions of visual and verbal components of working memory to episodic memory (Plancher et al., 2018). The participants were asked to memorize objects they encountered during a virtual city tour while simultaneously performing either a verbal or a visual working memory task. Accordingly, if two tasks utilize the same working memory component, performance would decrease due to overload in that component. According to their results, a simultaneous verbal working memory task made it difficult to encode only objects into episodic memory, whereas the visual working memory task interfered with both temporal encoding and contextualization. Therefore, visual and working memory tasks affect episodic memory performance at different times and in different ways (Plancher et al., 2018). However, episodic memory in this study was defined as correctly remembering objects, thus there was no direct mention of recalling one's specific past events. Ultimately, it remains poorly understood whether verbal working memory directly contributes to remembering personal past events.

The findings on the contribution of this component to future thinking are also limited. The contribution of the phonological loop to future thinking has mostly been studied with children by investigating the connection between verbal performances and episodic future thinking. For instance, in a study by Atance et al. (2019), preschoolers were asked to generate the appropriate item from a category that a toy hippo would like, verbally (e.g. they would verbally indicate that they intended to bring a pear from the fruit category). The researchers found a connection between verbal fluency and the ability to generate future scenarios. However, this connection diminished when the children were tested in a forced-choice condition where they had to choose a fruit from the options provided to them. These results indicate that verbal fluency plays a role in episodic foresight. In alignment with these results, receptive vocabulary skills also supported episodic future thinking in both children aged between 3-4 years and those aged 4-6 years (Cuevas, Rajan, Morasch & Bell, 2015; Naito & Suzuki, 2011). Furthermore, a study investigating the relationship among children aged 6 to 11 demonstrated a positive correlation between episodic future thinking and the improvement in verbal working memory. (Ferretti et al., 2018). The study measured phonological short-term and working memory using backward and forward digit span tasks, a non-word repetition task, and a subset of Wechsler Scales. Additionally, the Picture Book Trip task was employed to assess episodic future thinking measurement. The children were presented with four colored pictures (e.g. a waterfall) and asked to describe their contents. Each of the pictures thereafter was accompanied by three different photographs: a) a useful item (e.g. a watercoat), b) useless item in the given scenario (e.g. money), c) primed items (e.g. rocks). The children were encouraged to give details about the chosen objects and explain why they would be beneficial for the future. While the study found a significant facilitatory role of verbal working memory on episodic future thinking, it is noteworthy that scores in verbal working memory, assessed through three different tasks (forward digit-span, non-word repetition task, backward digit-span), accounted for only 9.6% of the variance in future thinking performance. Considering various studies indicating an increase in visual working memory performance with age in children (e.g., Heyes et al., 2012; Gathercole et al., 2004; Perlman et al., 2016; Simmering, 2012), it is more likely that the development of episodic future thinking may be influenced not only by verbal working memory development but also by the development of visual working memory. Moreover, since the connection between verbal working memory ability and episodic future thinking has been mostly studied with preschoolers, it is also necessary to investigate these connections in young adults. Consequently, further studies are needed to investigate this relationship in more depth.

1.4.4. Visuospatial Sketchpad

The visuospatial sketchpad allows for the mental manipulation of an object's color, shape, size, etc. The significance of visual imagery in episodic memory indicates that the visuo-spatial sketchpad is involved in recollecting past events. Studies suggest that episodic memory is primarily grounded in visual imagery, as the representation of past experiences is typically visual (Brewer, 1988; Conway, 2009; Rubin, Schrauf & Greenberg, 2003; Rubin, 2005; 2006). Rubin and colleagues (2003) observed that the more vivid the visual imagery in a particular memory, the stronger the episodic recall, which involves the feeling of reliving that moment by returning to a specific moment in the past. Another study tested this correlational finding with an experimental method, one group of participants experienced an event (e.g., a holiday planning process) in a laboratory environment blindfolded, while the other group experienced the same event without blindfolds. One week later, both groups were invited back to the laboratory and asked to recall the experience in the first phase. They then rated their episodic recall of this experience. As a result, it was found that blindfolded participants gave lower scores for the moment of recall compared to blindfolded participants. This finding is interpreted as episodic recall decreases when the visual information in the experience is removed (Rubin, Burt, & Fifield, 2003). There are also neuropsychological findings supporting the idea of the contribution of visual imagery in episodic memory. For example, Rubin and Greenberg (1998) described a novel form of amnesia resulting from the loss of the posterior neocortex rather than the medial temporal area. This amnesia type is characterized by the inability to access visual information, leading to a loss of memory. Patients with this syndrome may no longer be able to generate visual imagery associated with the memory, resulting in an inability to access the memory itself. A more recent study has also demonstrated the importance of visual imagery in episodic memory using a dual-task paradigm (Gatti et al., 2022). In this study, participants tried to remember past events in 3 different conditions (visual cognitive load, non-visual cognitive load, no cognitive load). In this study, where memory recall time (reaction time) was considered as the dependent variable, the non-visual cognitive load did not show any effect, while visual cognitive load made it difficult to come up with a memory. The other dual-task studies support these results, indicating that viewing dynamic visual noise (DVN) impairs the retrieval of specific memories due to shared cognitive taxation (Anderson et al., 2017; Sheldon et al., 2019). In a more recent study, Anthony et al. (2023) investigated the role of working memory and visual imagery in recalling memories separately, employing a dual-task methodology. Participants simultaneously recalled memories under three different conditions: tracking a moving dot, watching dynamic visual noise (DVN), and looking at a blank screen as a control condition. The researchers measured the retrieval times of the memories and their associated phenomenological characteristics (e.g., specificity, vividness, etc.). The results showed that both the DVN and moving dot conditions increased retrieval latency in comparison with the control condition. There was no discernible difference between the secondary task conditions, indicating that both working memory and visual imagery play a role in retrieval times. Additionally, the type of secondary task did not affect the phenomenological characteristics, possibly due to the procedure of the experiment. The participants attempted to recollect a personal past event concurrently, and the secondary task (DVN and following a moving dot) was terminated once an appropriate memory was found, similar to the procedure described in Gatti et al. (2022). Consequently, the effect of the secondary task on phenomenological characteristics would be diminished as the participants had enough time to elaborate on the event during the absence of the secondary task. Therefore, there is a need for further studies that utilize a secondary task during the elaboration of a past event.

While studies aimed at understanding episodic future thinking have not yet placed direct emphasis on the visual component of working memory, there are indirect findings that support this connection. The link between the visuospatial sketchpad and episodic future thinking can be inferred from the robust connection between visual information and episodic memory. Considering that episodic memory is largely based on visual imagery (Brewer 1988, Conway 2009, Rubin 2005), and that episodic memory forms the basis of episodic future thinking (Schacter & Addis 2007), both systems may require the utilization of the visual system in the brain. For instance, de Vito et al. (2015) had their participants simultaneously perform three types of secondary tasks (focusing on a moving dot, hand tapping, and free viewing) while engaging in remembering the past and imagining future events. Findings revealed fewer episodic details in the condition of focusing on a moving dot and engaging in a future thinking task compared to the control condition. Interestingly, the same secondary task did not affect the recollection of episodic memories in comparison with the future thinking condition. These results were likely observed due to the resource competition between voluntary eye movements, which involves visuospatial information processing (Postle et al., 2006; de Vito et al., 2014), and future thinking, which forms through the mental manipulation of visual imagery (El Haj & Lenoble, 2018; Conti & Irish, 2021). More recently, this interpretation has gained support from a neuroscience study using a graph-theoretical analysis, a mathematical method to analyze brain networks, by showing a strong connectome between the visual network and episodic future thinking (Hu et al., 2023). The results suggested that the visual network may even serve as a neural basis for future thinking. Additionally, Szpunar and his colleagues (2007) demonstrated that the network activated when envisioning the past shows similarities with the networks involved in attention and spatial working memory tasks. Ultimately, the findings may point out the crucial role of the visuospatial sketchpad component in the underlying cognitive mechanism of episodic future thinking.

1.5. The Present Study

Studies have shown that working memory capacity is linked to episodic future thinking (Hill & Emery, 2013; Cole et al., 2013; Zavagnin et al., 2016; Breeden et al., 2016; Bahri & Bahri, 2018). However, to date, only a few studies have investigated its components in the context of episodic memory and episodic future thinking. The studies examining the role of working memory components on episodic future thinking have also been limited to the central executive, episodic buffer, and phonological loop components. Therefore, it is unclear whether visual working memory plays a role in episodic future thinking. Although still limited in number, there are also studies in the literature that focus on the role of verbal and visual components in episodic memory and examine these components comparatively (e.g., Janssen et al., 2015; Plancher et al., 2018). However, to the best of our knowledge, no study has comparatively examined the role of visual and verbal components in episodic future thinking. Thus, the present study is the first attempt to distinguish between visual and verbal components for the investigation of future thinking. Given the prominent hypothesis of constructive episodic simulation which posits that future thoughts are formed through episodic details stored in episodic memory and that the crucial role of visual information in episodic memory, episodic future thinking may also rely on visual information (Brewer, 1988; Conway, 2009; Rubin, Schrauf & Greenberg, 2003; Rubin, 2005; 2006). Indeed, some studies point to the pivotal role of visuospatial information processing in episodic future thinking (Szpunar et al., 2007; Vito et al., 2015; El Haj & Lenoble, 2018; Conti & Irish, 2021; Hu et al., 2023). Therefore, it is plausible that visuospatial working memory holds a stronger association with future thinking compared to verbal working memory. Therefore, the primary objective of this study is to investigate the potential roles of verbal and visual working memory on episodic future thinking in a between-group comparison. A dual-task procedure was employed for this investigation, in which participants were assigned to perform either visual or verbal working memory tasks concurrently with the episodic memory and episodic future thinking tasks. The construction of these future events was measured with reaction time latencies, and phenomenological characteristics were rated for those events.

Accordingly, the main hypothesis of this study is as follows:

H1: Performing episodic future thinking and visual working memory tasks simultaneously will result in higher reaction times (H1a) and poorer phenomenological evaluations (H1b) compared to performing episodic future thinking and verbal working memory tasks simultaneously while controlling the effect of working memory capacity.

The studies to date testing the constructive episodic simulation hypothesis have uncovered various similarities (Szpunar, Watson & McDermott, 2007; Race, Keane & Verfaellie, 2011; Schacter et al., 2013; Bertossi, Tesini, Capelli & Ciaramelli, 2016; Cole et al., 2016), and differences (D'Argembeau & Van der Linden, 2004; D’Argembeau, Lardi, & Van der Linden, 2010; Arnold, McDermott & Szpunar, 2011), between episodic future thinking and episodic memory. However, the question of whether there is parallelism or divergence between episodic future thinking and episodic memory concerning working memory components remains unexplored. If episodic future thinking is more cognitively demanding and taxes working memory resources more than episodic memory, this may stem from the differential usage of working memory components. A dual-task study showed that visuospatial information processing load interferes more with episodic future thinking than with episodic memory (Vito et al., 2015). Therefore, the visuospatial component is likely to be more heavily utilized for future thinking than for episodic memory. Accordingly, the second goal of the project is to determine how different working memory components support episodic memory and episodic future thinking separately through within-group comparison. For this purpose, each participant performed both an episodic future thinking and an episodic memory task. The construction of these past events was measured using reaction time latencies, and phenomenological characteristics were rated for those events, just as they were for future events. Ultimately, the second hypothesis of this study is as follows:

H2: Performing visual working memory and episodic future thinking tasks simultaneously will result in higher reaction times (H2a) and poorer phenomenological evaluations (H2b) compared to performing visual working memory and episodic memory tasks simultaneously, while controlling the effect of working memory capacity.

CHAPTER II

2. Method

2.1. Participants

The sample size was calculated employing the widely used practice for analysis of covariance (see Cohen, 1988, p. 379; Huitema, 2011, p. 475). The sample size was calculated using MorePower 6.0.4 software, which is suitable for power analysis according to our experimental design (Campbell & Thompson, 2012). The analysis indicated that the sample size for the 2 (between subjects: visual and verbal) x 2 (within-subjects: past remembering and future thinking) x 2 (within-subjects: single-task and dual-task) mixed design analysis of covariance should include a minimum of 168 participants to achieve a power of .90, with an alpha error value of .05 and a medium effect size of Cohen's *f* = .25 (Cohen, 1988). However, considering the potential loss of participants that may occur due to various reasons, at least 15% more than the calculated maximum number of participants was aimed. One hundred ninety-three undergraduate students (171 female, 21 men, 1 not specified; mean age = 21.4 years, *SD* = 2.09, range 18 to 29) who were native Turkish speakers and normal or corrected-to-normal vision from Istanbul Medipol University participated in the study in return for course credits. 68% of the participants reported sleeping for over 6 hours, and 71% had their last meal within 4 hours before joining the study. Right-handed, left-handed, and ambidextrous participants accounted for 90.7%, 7.3%, and 2.1% respectively.

2.2. Experimental Design

We employed a mixed design with 2 (working memory components: visual and verbal) between groups x 2 (temporal direction: episodic future thinking, episodic memory) within group x 2 (task type: single-task, dual-task) within group variables. Accordingly, participants were randomly assigned to two groups (either visual or verbal) and each participant performed a visual or verbal working memory task concurrently with the episodic future thinking and episodic memory tasks (dual-task). Before the tasks were performed simultaneously, each task (working memory, episodic future thinking, and episodic memory tasks) was performed alone (single-task). The dependent variables of the study were the duration of recollection/construction of thoughts and the associated phenomenological ratings.

2.3. Materials

2.3.1. 2-back Task

A 2-back task was used to examine the roles of verbal and visual components of working memory to episodic future thinking. This paradigm, designed by Kirchner (1958), is often used to create a modality-specific load in working memory (Ozbozdaglı, Misirlisoy, Ozkan and Atalay, 2018; Owen, McMillan, Laird & Bullmore, 2005). This paradigm has both a verbal and a visual version (Jaeggi et al., 2010). The verbal and visual 2-back tasks were adapted from Jaeggi and her colleagues' study (2010). In the verbal version of the 2-back paradigm, the letters were read to the participant through headphones, while in the visual version, participants were shown squares that appeared in different positions on the computer screen (Jaeggi et al., 2010, Ozbozdagli et al., 2018). Participants were instructed that they should determine whether the square or letter presented two digits before is the same as the square or letter presented at that moment (see Appendix A). For example, after hearing each letter or seeing each square, the participants were expected to decide whether the letter or square on the screen at that moment was the same as the stimulus shown two steps ago by pressing the "H" key on the keyboard. For example, while the participant heard the letter sequence "P K F **K** C R Z N **Z** Y Y" one by one, he/she had to press the "H" key when he/she heard the letters written in bold font, but he/she did not have to press any key for the other letters (or squares). During the experiment, each letter or square was presented for 500 ms (milliseconds) and after a 2500 ms interval, the next letter or square was shown. Therefore, the participant had a maximum of 3000 ms per trial to press the "H" key. This key was chosen as it is in the center of the keyboard, thus eliminating the potential effects of handedness.

Although this task is not often used to assess verbal and visual working memory separately, it can also be considered as a secondary task in dual-task paradigms. In a recent dual-task study by Ozbozdaglı, Misirlisoy, Ozkan and Atalay (2018), participants performed a car driving task (simulation) as a primary task while performing an auditory 2-back or visual 2-back task as a secondary task. The study concluded that the type of secondary task that the driver is engaged in can affect driver performance. Some studies also support the idea that modality-specific n-back tasks could activate different brain areas (Owen, McMillan, Laird & Bullmore, 2005; Rodriguez-Jimenez et al., 2009). This suggests that both visual and verbal tasks activate frontal regions, but each task is primarily related to either verbal or visual brain areas (Owen, McMillan, Laird & Bullmore, 2005). Thus, it is evident that the 2-back tasks can serve as a secondary task to induce cognitive load within the respective modalities.

2.3.2. Episodic Future Thinking Task

The episodic future thinking task was adapted from previous studies (e.g., D'Argembeau & Mathy, 2011; D'Argembeau & Van der Linden, 2006) and modified to use in the dual-task paradigm. In this task, participants were shown a cue word and asked to construct a future event related or unrelated to the cue word. As soon as the participant comes up with an event after seeing the cue word, he/she presses the "SPACE" key and expresses the event very briefly, in 2-3 words, out loud. This method allowed us to verify if the participant had indeed formed an event and measure the reaction time (in milliseconds). The participants then silently tried to elaborate on this event in their minds for 30 seconds, and after the time was over, they were prompted with phenomenological questions (Addis et al., 2007; Janssen et al., 2021). If a participant didn't press the "SPACE" button within 15 seconds following the cue word presentation, the remaining parts of the trial were skipped. This duration was determined as a result of the pilot study's average.

The participants were instructed that these future-oriented events can be pre-planned or imagined; what is important is that they must be plausible events that could happen in the future. It was also emphasized that they should be a specific event taking place at a specific time and place (see Appendix A). To promote the formation of future thoughts, 12 concrete and neutral words with proximal values of imageability (Min. = 6.44, Max. = 6.87, *M* = 6.64; *SD* = 0.15) and concreteness (Min. = 6.64, Max. = 6.96, *M* = 6.85; *SD* = 0.10) were selected from a pool consisting of 800 words (Ersoy & Tekcan, 2018). The cue words used in the practical stages were not used in the experimental phases (see Appendix B).

To ensure the cue words were presented in the same format and timing for both groups during the dual-task, it was decided to display them during interstimulus intervals in the written format. The cue words appeared in the center of the screen for 1000 ms (Gatti et al., 2022; Anthony et al., 2023). The font type, color, and size were Arial, white, and 40, respectively. After the cue word presentation, the participant was expected to press the "SPACE" key when an event came to mind. The interval between the display of the cue word and the pressing of the "SPACE" key was recorded as the reaction time (ms). Immediately after pressing the button, the participants were prompted with a white screen lasting 5 seconds, where they had to summarise the event very briefly, using 2-3 words. At this stage, the participant's summaries were recorded by the computer through a microphone. If participants were unable to verbally report the event, it was considered that they could not form a future thought, and the reaction time measurement was coded as missing data in the dataset. In this way, a concrete criterion was established that the participants indeed performed the task.

In the literature, there are various studies published in high-impact scientific journals based on reaction time measurement in the dual-task paradigms. For example, in one study, the speed (reaction time) of constructing episodic future thought, which was considered as a primary task, was measured in a dual-task setting (Anderson et al., 2012). In their study, participants were instructed to generate specific future events or remember specific past events with the help of either high imageability or low imageability cue words, while doing random number generation as a secondary task. The results of three separate experiments indicated that future thinking was a lengthier and more error-prone process than past remembering, thus it might place greater demand on executive resources to some extent. In another dual-task study, the speed of recalling autobiographical memories was considered as a primary task (Gatti et al., 2022). The study employed three types of secondary tasks; visual search task, random number generation, and no-cognitive load. Participants were asked to find a past event after seeing the cue word while doing the secondary tasks. Interestingly, the study found that the visual search task significantly slowed direct and generative episodic retrieval while random number generation had no specific effect on retrieval time. These and similar studies support the idea that measuring the speed of recollection of episodic future thought and/or episodic memory tasks in dual-task paradigms can be a reliable method.

2.3.3. Episodic Memory Task

The episodic memory task was adapted from previous studies (e.g. Addis et al., 2007; D'Argembeau & van der Linden, 2006) and modified to use in the dual-task paradigm. The procedure of this task was identical to the episodic future thought task except for the instructions. In this task, the participants were asked to recall a memory from the past related or unrelated to the cue word. As in the episodic future thinking task, the participants were instructed to construct a specific event that happened at a specific time and in a specific place.

2.3.4. Phenomenological Questions

Participants were prompted with 13 questions about the vividness, sensory details, emotional valence, etc. of the past and future events that they silently elaborated in their minds for 30 seconds (e.g. "*This is a vivid event*" 1 = not at all, 7 = to a very high degree; "*As I imagine the event, I can see it in my mind*" 1 = not at all, 7 = as clearly as if it were happening now; "*The emotions I have when I imagine the event are"* (1 = very negative, 7 = very positive, etc.,). Each question remained on the screen for a maximum of 20 seconds. Participants answered the questions by pressing the 1-7 keys on the top of the keyboard. The questions were modified according to temporal direction (see Appendix C)

These questions are frequently used in the literature and aim to measure the phenomenological characteristics of mental time travel (D'Argembeau & Van der Linden, 2006; Akdere & Ikier, 2021; Özbek et al., 2017; Özbek et al., 2018). There are also examples in the literature where episodic future thinking and episodic memory tasks are performed silently and then their phenomenological characteristics are measured (Addis et al., 2007; Janssen et al., 2021).

2.3.5. Automated Operation Span Task

To control individual differences in the central executive component and general working memory capacity, an automated operation task was used (Unsworth et al., 2005). In the task, the participants had to remember a series of letters (storage component) while concurrently engaging in a cognitive task (verification of math equation accuracy; processing component). After each decision on whether the math equation was correct or not, a letter was presented for 800 ms, and the participants had to memorize it for the following test. Each trial consisted of a set of three to seven processing-storage components, followed by a memory test. In the memory test, participants were presented with a 4x3 matrix containing all potential letters, and they were instructed to select the letters in the correct sequential order by clicking on them. If participants couldn't recall the exact order, they could press the "blank" button to indicate the forgotten letter. The software automatically computed the average time taken by participants to verify math equations in the practice stages and then added 2.5 standard deviations (SD) to this mean time to establish a time limit for each participant in the experimental phase. The task consisted of three practice stages: 4 letter remembering trials (only storage), 15 math equation verification trials (only processing), and 3 concomitant trials (storage and processing). Participants then completed 15 experimental trials (varied from 3 to 7 set sizes for each trial). This task has been repeatedly shown to measure working memory capacity reliably and validly (Redick et al., 2012; Unsworth et al., 2005).

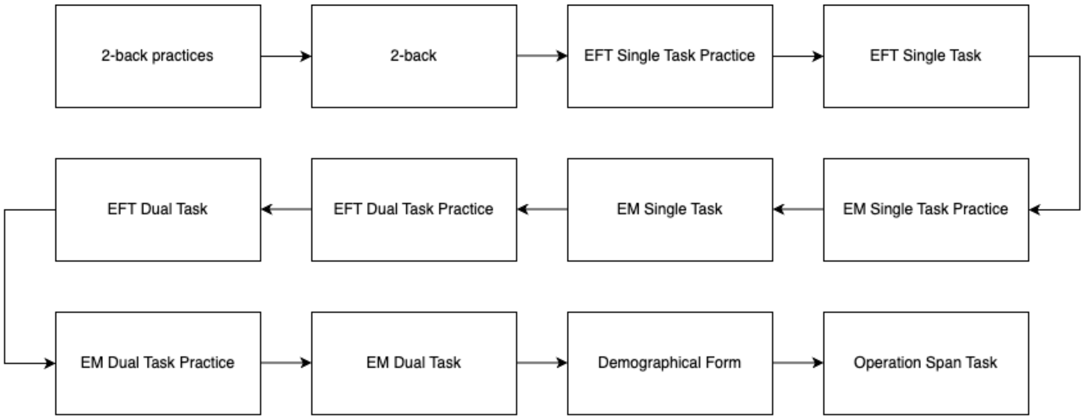
2.3.6. Demographical and Strategy Evaluation Form

The demographic questionnaire in this study includes questions about age, sex, handedness, and whether they used any strategies during the experiment (see Appendix D). The strategy questions aimed to check at the end of the experiment whether the participants made a categorization or clustering while retaining the stimuli in the 2-back task, whether they constructed the episodic future thought before seeing the cue word, and whether they continued to construct while answering the questionnaire question. We also asked our participants how long they slept last night and how many hours before the experiment they had eaten.

2.4. Procedure

The experiment was programmed and conducted through E-Prime 2.0 Software. The tasks were completed on the computer in the Psychology Laboratory and the participants were tested individually. The completion of the task was approximately 45 minutes. All participants were seated in front of the computer and put the headset on. Participants were randomly assigned to visual and verbal groups. Participants in the verbal group heard the letters through headphones but participants in the visual group did not hear any sound. All participants first filled out the informed consent form. Afterward, they were informed about the study verbally and proceeded to the experiment with written instructions. The study's flowchart is presented in Figure 1.

Figure 1. The flowchart of the study.



The participants completed a practical and an experimental phase for each task. After the successful completion of the practice phase, the experimental phase began in which the actual measurements were taken. Initially, participants practiced single-tasks before moving on to dual-tasks. In both single and dual-tasks, half of the participants first received the episodic future thinking task, while the other half began with the episodic memory task. Thus, potential effects that may have arisen from the order of past and future tasks were prevented.

2.4.1. Single-task procedures

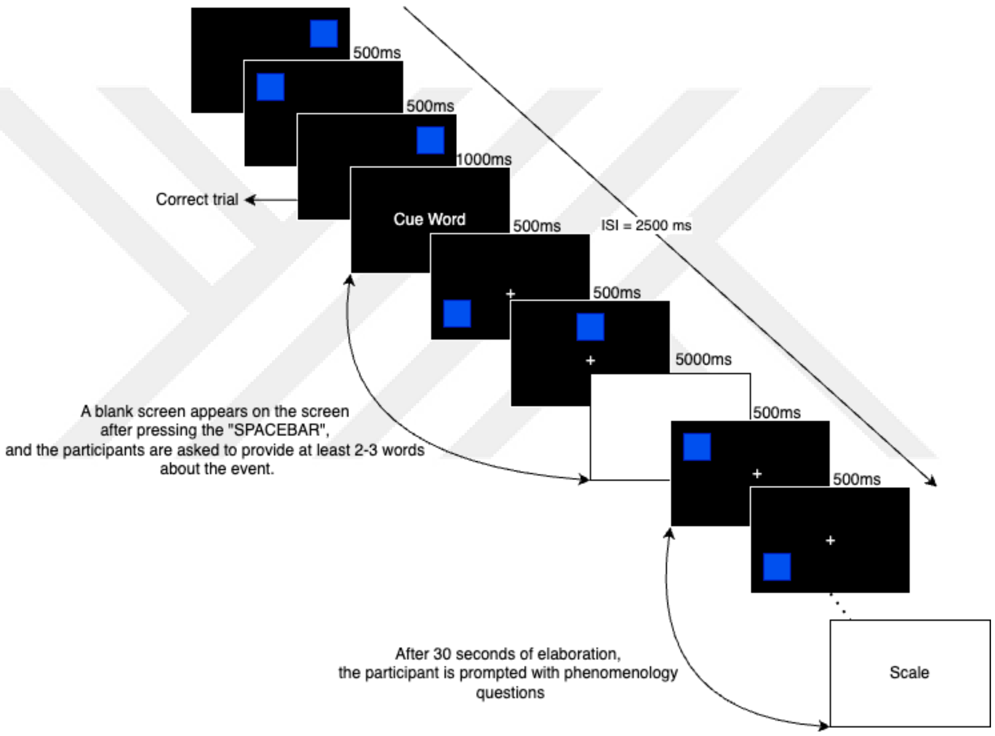
The single-task procedure started with the practice phase of the 2-back task. Both written and visual instructions were used to help participants better understand the task. After the instructions, participants completed 15 trials of the 2-back (4 targets, 11 non-targets). Participants who accomplished 80% of the 2-back trials proceeded to the experimental stage where 20 trials of the 2-back (5 targets, 15 non-targets) were presented. Those who did not meet the 80% criterion repeated the practice set with additional instruction before moving to the experimental phase.

After completing the 2-back trials, the participants progressed to the practice phase of the episodic future thinking or episodic memory task. In the practice phase, participants were given written instructions and asked whether he/she understood the task. Participants who did not understand the task were informed verbally again. When the practice phase started, a fixation point appeared in the center of the screen, and then a cue word was presented for a brief time. Immediately after the cue word presentation, the fixation point reappeared and remained on the screen until the participant came up with a memory/future thought and pressed the "SPACE" key. Following the button pressing, the screen turned to a blank white screen and the participant briefly summarized the event out loud. The software recorded this summary through the microphone. Then he/she was asked to elaborate on this event in his/her mind. After the completion of the elaboration phase, phenomenology questions were presented on the screen. Once the phenomenology questions were answered, the experimental phase commenced, during which actual measurements were obtained. The procedure of the experimental phase remained consistent with that of the practice phase. Upon completion of this stage, the next task involved participants practicing for the other task, either the episodic future thought or episodic memory task. This task was the same as the previous task except the instructions given to the participant. Following the single-task trials, participants progressed to the dual-task procedures.

2.4.2. Dual-task procedures

Participants initially began with either episodic memory or episodic future thinking dual-task practice. In this task, participants were expected to try to perform two different tasks they had learned concurrently (see Figure 2). The procedure started with a practice stage comprising 20 trials of 2-back. While participants are engaged in the 2-back task, it briefly pauses, and a cue word is displayed in the center of the screen. After the cue word presentation, the 2-back task started again. At this stage, the participant tried to remember/imagine an event while trying to continue the 2-back task. When an event came to the participant's mind, they pressed the "SPACE" key and the 2-back task stopped again for a brief time. At this point, the participant summarised the event in a few words while looking at the blank white screen, out loud. This summary was recorded by E-prime through the microphone. Then the 2-back task continued again. In the meantime, the participants were asked to continue to detail the event in their minds while monitoring the 2-back sequence. Subsequently, phenomenology questions were presented on the screen after the elaboration stage. Following these questions, the practice phase concluded, and the experiment phase began. The same procedure was applied in both the practical and experimental phases. After completing the first stage (practice + experiment) of the dual-task, participants proceeded to practice for the next dual-task stage (either episodic memory or episodic future thinking). The procedures were the same as the previous stage except for the instruction given to the participant. Upon completing the final dual-task stage, participants were asked to fill out the Demographic Information and Strategy Evaluation Form. Subsequently, participants were given a short break before commencing the new task. Lastly, participants performed the automated operation task.

Figure 2. The dual-task procedure of the visual group.



CHAPTER III

3. Results

3.1. Data Exclusion and Handling Missing Data

Four participants could not complete the operation span task and were excluded from the analysis. To improve the reliability of our reaction time analyses, we excluded cases where participants failed to report a past event (4 cases) or a future event (9 cases) after pressing the button in the single-task condition. Similarly, in the dual-task condition, we excluded cases where participants failed to report a future event (8 cases) or a past event (7 cases) after pressing the button for the same purpose. We also excluded the trials where participants reported a past event (4 cases) and a future event (3 cases) before pressing the button in the single-task condition, as well as in the dual-task condition of future thinking (1 case). Additionally, we removed outliers from the dual-task of past remembering (11 cases) and future thinking (4 cases) to ensure normality in our data. For phenomenology analyses, we excluded responses from a total of 38 participants who did not report an event for any of the 14 scale questions in the questionnaire[1].

The proportion of missing values for the reaction times of the single-tasks of future events and past events were 28.5% and 29.0%, respectively. Moreover, for the dual-tasks involving both future and past events, these proportions were 18.1% and 18.7%, respectively. The proportion of incomplete cases was 58.55%. Therefore, the study's sample size available under complete case analysis would only be eighty-seven participants in total for reaction time and phenomenology analyses of three-way covariance, which might have reduced the power of the study and thus led to biased estimates[2]. Therefore, we addressed these missing values using the multiple imputation technique[3]. IBM SPSS Statistics 21 was used for both the multiple imputation and statistical analyses[4].

3.2. Hypothesis Testing

In this section, we first test our hypotheses, and then present exploratory analyses. Regarding the hypothesis testing, we first describe the reaction time data (the interval between seeing the cue word and pressing the button) and probe the main effects and interactions. Subsequently, we investigate phenomenology data, where participants

[1] We included trials where participants reported an event before pressing the button. The reason for this inclusion was the assumption that the participants had indeed come up with an event but remembered the button pressing only after reporting the event.
[2] Analyzing only the participants who completed all trials (i.e. complete case analysis), might lead to biased results due to the reduced power (.63), and could increase the type II error. However, for those who might be interested, we also reported the complete case analyses in Appendix E.
[3] The reason for these missing cases in our data is due to the limited number of trials. This issue will be elaborated in the discussion.
[4] We conducted imputation for each variable employing multiple chained equations (MICE) technique 5 times. Approximately 30 and 50 values imputed for dual and single-task conditions, respectively.

evaluated the events that they reported. In the exploratory analyses, we examine the effects of secondary tasks by comparing single-task and dual-task conditions.

3.2.1. Reaction Time

A three-way mixed ANCOVA was performed to investigate how visual and verbal secondary tasks affect the reaction time for episodic future thinking and episodic memory tasks while controlling the effect of working memory capacity. We first centered the covariate as our experiment includes within-subject factor (Delaney & Maxwell, 1981; Schneider et al., 2015). The descriptive statistics are summarized in Table 1. There was no three-way interaction between temporal direction, task type and group $F(1, 185) = 3.20$, $p = .08$, $\eta_p^2 = .017$. The three-way interaction between temporal direction task type and operation span was also not significant $F(1, 185) = 0.00$, $p = .99$, $\eta_p^2 = .000$. Two-way interaction analysis showed that there was an interaction between groups (visual/verbal) and temporal directions $F(1, 185) = 6.10$, $p < .05$, $\eta_p^2 = .032$. Pairwise comparisons of the estimated marginal means indicated that the reaction time for past events was longer in the visual group (M = 5503.84, SD = 215.809) than in the verbal group (M = 4877.67, SD = 206.66); p = .039, %95 C.I. = [31.61, 1220.71][5.] Additionally, in the verbal group, it took more time to imagine future events (M = 5692.48, SD = 254.30) than remembering past events (M = 4877.67, SD = 206.66); $p < .001$, %95 C.I. = [443.04, 1186.57]. The remaining two-way interactions were not significant; temporal direction and task type $F(1, 185) = 0.57$, $p = .39$, $\eta_p^2 = .003$, task type and group $F(1, 185) = 0.07$, $p = .79$, $\eta_p^2 = .000$, temporal direction and operation span $F(1, 185) = 0.78$, $p = .38$, $\eta_p^2 = .004$. We observed a main effect of temporal direction $F(1, 185) = 12.40$, $p = .001$, $\eta_p^2 = .063$. This analysis suggests that imagining future events (M = 5666.1, SD = 182.25) were slower than remembering past events (M = 5190.76, SD = 148.1). Lastly, the main effect of task type was also significant $F(1, 185) = 50.48$, $p < .001$, $\eta_p^2 = .214$. The time spent on finding an event during the single-task condition (M = 6179.66, SD = 200) took more time compared to dual-task condition (M = 4677.28, SD = 168.43)[6].

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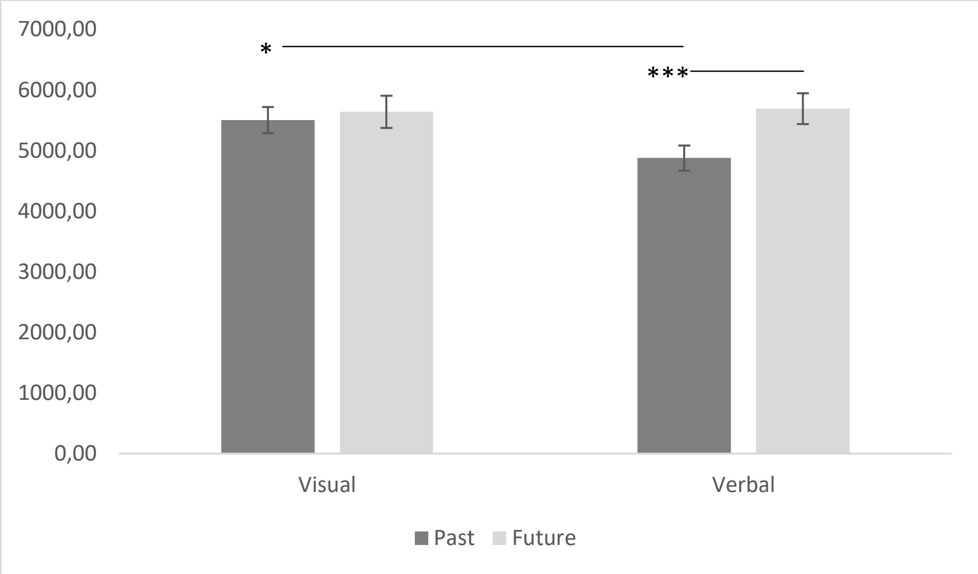
[5] The comparisons were Bonferroni-corrected in here as well as in other analyses.
[6] This unexpected finding is discussed in the discussion section.

Overall, reaction time analyses showed that constructing future events took more time than constructing past events, and this difference was particulary pronounced in the verbal group (Fig. 1). Additionally, constructing past events were slower in the visual group than verbal group.

Table 1. Descriptive statistics for reaction times.

	Conditions	Groups	*M*	*SD*	*N*
Past Events	Single-task	Visual	6460.65	3170.6	90
		Verbal	5536.01	2720.3	98
		Total	5978.66	2972.8	188
	Dual-task	Visual	4568.17	2405.3	90
		Verbal	4199.94	2113.5	98
		Total	4376.22	2259.3	188
Future Events	Single-task	Visual	6232.70	3577.2	90
		Verbal	6488.63	3161.9	98
		Total	6366.11	3360.5	188
	Dual-task	Visual	5114.76	2982.3	90
		Verbal	4834.18	2736.9	98
		Total	4968.50	2852.8	188

Figure 3. The differences in reaction time for events between groups.



* $p < .05$; *** $p < .001$

3.2.2. Phenomenology

A three-way mixed ANCOVA was performed to investigate how visual and verbal secondary tasks affect the phenomenology of episodic future thinking and episodic memory events while controlling the effect of working memory capacity. The covariate was centered before running the analyses. The descriptive statistics are summarized in Table 3.

Table 2. Descriptive statistics of phenomenology ratings.

		Past Events				Future Events				
		Single		Dual		Single		Dual		
Items	Groups	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*N*
Vividness	Visual	5.54	1.527	5.45	1.496	5.51	1.348	5.40	1.524	90
	Verbal	5.81	1.207	5.27	1.589	5.59	1.454	5.46	1.453	98

	Total	5.68	1.373	5.36	1.544	5.55	1.401	5.43	1.483	188
	Visual	5.28	1.495	5.05	1.642	4.89	1.727	4.64	1.748	89
Pre/Re-Experiencing	Verbal	5.30	1.541	4.88	1.693	5.20	1.572	4.71	1.828	98
	Total	5.29	1.515	4.96	1.666	5.05	1.650	4.68	1.786	187
	Visual	5.95	1.085	5.61	1.305	5.85	1.167	5.57	1.278	90
Visual Imagery	Verbal	5.89	1.125	5.69	1.271	5.78	1.156	5.64	1.478	98
	Total	5.92	1.104	5.65	1.285	5.82	1.159	5.61	1.382	188
	Visual	5.24	1.727	4.66	1.915	5.09	1.635	4.74	1.950	90
Auditory Imagery	Verbal	5.38	1.553	4.70	1.943	4.87	1.716	4.95	1.824	98
	Total	5.32	1.635	4.68	1.924	4.97	1.677	4.85	1.883	188
	Visual	5.69	1.514	5.30	1.512	5.34	1.502	4.91	1.653	90
Spatial Imagery	Verbal	5.73	1.268	5.28	1.607	5.28	1.535	5.15	1.620	98
	Total	5.71	1.388	5.29	1.558	5.31	1.515	5.04	1.636	188
	Visual	4.82	1.727	4.59	1.704	4.40	1.705	4.43	1.738	90

Emotional Intensity	Verbal	4.68	1.770	4.48	1.688	5.06	1.735	4.74	1.785	98
	Total	4.75	1.746	4.53	1.692	4.75	1.748	4.59	1.765	188
Valence	Visual	4.83	2.007	4.47	2.091	4.91	1.708	4.89	1.862	90
	Verbal	4.44	2.029	4.35	1.970	5.10	1.919	5.03	1.871	98
	Total	4.63	2.023	4.41	2.024	5.01	1.819	4.97	1.863	188
Personal Importance	Visual	4.22	1.957	3.66	1.872	3.79	1.970	3.75	1.879	90
	Verbal	4.07	1.830	3.57	1.999	4.59	2.010	4.18	1.886	98
	Total	4.14	1.889	3.61	1.934	4.21	2.026	3.98	1.890	188
Voluntary Rehearsal	Visual	3.78	1.802	3.41	1.885	3.32	1.891	3.31	1.854	90
	Verbal	3.88	1.878	3.41	1.802	3.90	2.075	3.85	2.232	98
	Total	3.83	1.838	3.41	1.837	3.63	2.005	3.59	2.072	188
Involuntary Rehearsal	Visual	4.36	1.944	4.48	1.896	4.12	1.793	4.13	1.819	90
	Verbal	4.70	1.877	4.29	1.822	4.37	1.969	4.81	1.785	98
	Total	4.54	1.912	4.38	1.855	4.25	1.886	4.49	1.829	188

	Visual	5.69	1.403	5.17	1.710	5.53	1.211	5.17	1.611	90
Ease Of Imagining	Verbal	5.80	1.260	5.22	1.697	5.78	1.319	5.32	1.680	98
	Total	5.75	1.327	5.20	1.698	5.66	1.271	5.25	1.645	188
	Visual	3.33	2.208	3.34	2.382	3.73	2.374	3.38	2.314	89
Imagery Perspective	Verbal	3.28	2.318	3.13	2.345	3.52	2.398	3.01	2.348	98
	Total	3.30	2.260	3.23	2.359	3.62	2.383	3.18	2.333	187
	Visual	5.98	1.538	5.68	1.847	5.61	1.608	5.75	1.524	90
Specificity	Verbal	6.11	1.427	6.10	1.236	5.78	1.373	5.68	1.511	98
	Total	6.05	1.479	5.90	1.569	5.70	1.489	5.71	1.513	188

3.2.2.1. Vividness

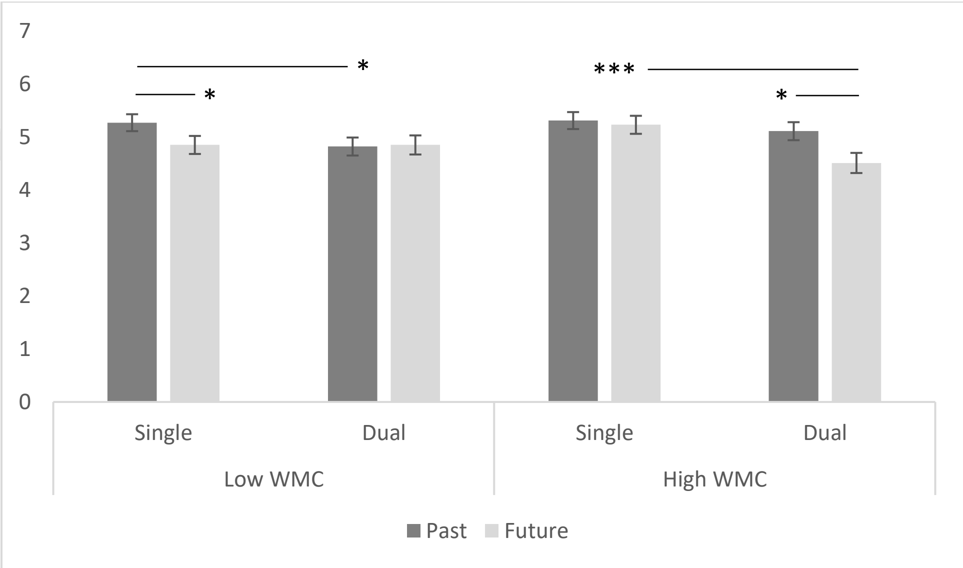
The analysis results revealed no three-way interaction both between temporal direction, task type, and operation span $F(1, 185) = 0.94$, $p = .33$, $\eta_p^2 = .005$, as well as between temporal direction, task type, and group $F(1, 185) = 2.07$, $p = .15$, $\eta_p^2 = .011$. There was also no two-way interaction effect; the interaction between temporal direction and task type $F(1, 185) = 1.26$, $p = .26$, $\eta_p^2 = .007$, task type and group $F(1, 185) = 1.14$, $p = .28$, $\eta_p^2 = .006$, task type and operation span $F(1, 185) = 0.43$, $p = .51$, $\eta_p^2 = .002$, temporal direction and group $F(1, 185) = 0.50$, $p = .82$, $\eta_p^2 = .000$ and temporal direction and operation span $F(1, 185) = 0.31$, $p = .57$, $\eta_p^2 = .002$. The main effect of task type was significant $F(1, 185) = 4.78$, $p < .05$, $\eta_p^2 = .025$. The participants rated less vividness for the events they imagined in the dual-task condition ($M = 4.76$, *SD* = .11) than in the single-task condition (*M* = 5.14, *SD* = .07). Lastly, there was no main effect of temporal direction $F(1, 185) = 0.73$, $p = .39$, $\eta_p^2 = .004$. These results suggest that only the type of task affects the vividness of the events, indicating that dual-tasking decreases the vividness of the events regardless of the temporal direction and the group (visual/verbal).

3.2.2.2. Pre/Re-experiencing

The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 184) = 0.21$, $p = .64$, $\eta_p^2 = .001$. The three-way interaction between temporal direction, task type and operation span were significant $F(1, 184) = 16.90$, $p < .05$, $\eta_p^2 = .041$. The two-way interaction between temporal direction and task type was not significant $F(1, 184) = 0.68$, $p = .79$, $\eta_p^2 = .000$, suggesting that the interaction between temporal direction and task type is only observed with the effect of operation span. To delve into this interaction, we categorized operation span as "high working memory capacity" and "low working memory capacity" using a median split and re-run the three-way interaction analysis. The analysis revealed a three-way interaction between temporal direction, task type and categorized operation span $F(1, 185) = 5.40$, $p < .05$, $\eta_p^2 = .028$. Pairwise comparisons revealed that in the single-task condition, participants with low working memory capacity rated future events (*M* = 4.85, *SD* = .17) lower than past events (*M* = 5.27, *SD* = .16) in pre/re-experience ($p < .05$, %95 C.I. = [-.81, -.02]). The same pattern were also observed in the dual-task condition among participants with higher working memory capacity. The results showed that in the dual-task condition, participants with higher working memory capacity rated future events (*M* = 4.51, *SD* = .19) lower than past events (*M* = 5.11, *SD* = .17) in pre/re-experience ($p < .05$, %95 C.I. = [-1.059, -.140]). Additionally, the participants with higher working memory capacity rated less pre-experience in future events in the dual-task condition (*M* = 5.26, *SD* = .17) compared to single-task condition (*M* = 4.51, *SD* = .19); $p < .05$, %95 C.I. = [-1.152, -.358]. Lastly, those with lower working memory capacity rated past events as less re-experienced in the dual-task condition (*M* = 4.82, *SD* = .17) compared to to the single-task condition (*M* = 5.27, *SD* = .16); $p < .05$, %95 C.I. = [-.891, -.001].

Overall, it appears that pre-experiencing future events is more difficult than re-experiencing past events, and the dual-task cost impacts pre/re-experiencing future and past events differently depending on one's working memory capacity (Fig. 2). Accordingly, participants with lower working memory capacity were affected by the dual-task cost for past events but not for future events. Conversely, those with higher working memory capacity were affected by the dual-task cost for future events but not for past events.

Figure 3. Illustration of the three-way comparison of pre/re-experiencing ratings across low and high working memory capacity groups.



* $p < .05$; *** $p < .001$

The two-way interactions between temporal direction and task type $F(1, 184) = 0.06$, $p = .79$, $\eta_p^2 = .000$, task type and group $F(1, 184) = 0.96$, $p = .32$, $\eta_p^2 = .005$, task type and operation span $F(1, 184) = 0.00$, $p = .94$, $\eta_p^2 = .000$., temporal direction and group $F(1, 184) = 2.00$, $p = .15$, $\eta_p^2 = .011$ and temporal direction and operation span $F(1, 184) = 1.48$, $p = .23$, $\eta_p^2 = .008$., were not significant. The main effect of task type was significant $F(1, 184) = 10.33$, $p < .01$, $\eta_p^2 = .053$. Pairwise comparisons showed that the participants rated more pre/re-experiencing in the single-task condition ($M = 5.17$, $SD = .09$) than in the dual-task condition ($M = 4.82$, $SD = .10$). The main effect of temporal direction was also significant $F(1, 184) = 5.96$, $p < .05$, $\eta_p^2 = .031$. Accordingly, the participants rated less pre-experience for future events ($M = 4.86$, $SD = .10$) than past events ($M = 5.13$, $SD = .09$). The results suggest that the feeling of pre-experiencing decreases when there is relatively high cognitive demand, and individuals pre-experience future events worse than they re-experience past events.

3.2.2.3. Visual Imagery

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 0.02$, $p = .89$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 185) = 0.68$, $p = .41$, $\eta_p^2 = .004$. Two-way interactions were also not significant; temporal direction and task type $F(1, 185) = 0.76$, $p = .76$, $\eta_p^2 = .001$, task type and group $F(1, 185) = 0.49$, $p = .49$, $\eta_p^2 = .003$, task type and operation span $F(1, 185) = 1.11$, $p = .29$, $\eta_p^2 = .006$, temporal direction and group $F(1, 185) = 0.03$, $p = .87$, $\eta_p^2 = .000$, and lastly temporal direction and operation span $F(1, 185) = 0.20$, $p = .65$, $\eta_p^2 = .001$. There was a main effect of task type $F(1, 185) = 10.42$, $p = .001$, $\eta_p^2 = .053$. Accordingly, the participants rated less visual imagery for the events they imagined/remembered in the dual-task condition ($M = 5.63$, $SD = .08$) than in the single-task condition ($M = 5.86$, $SD = .06$). The main effect of temporal direction was not significant $F(1, 185) = 0.89$, $p = .35$, $\eta_p^2 = .005$. It appears that visual imagery is only influenced by the type of task, indicating that the dual-task cost decreases visual imagery, regardless of the temporal direction and the group (visual/verbal).

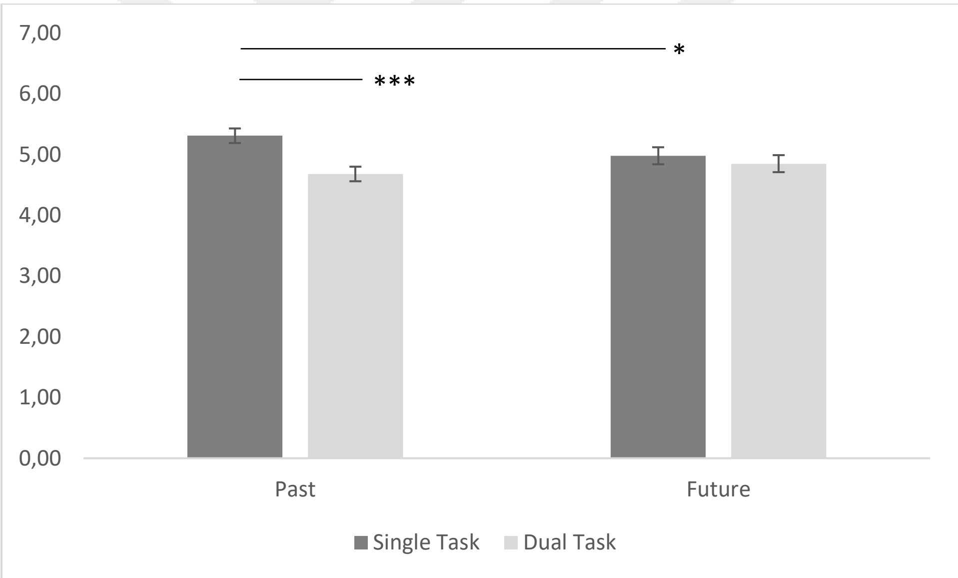
3.2.2.4. Auditory Imagery

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 2.18$, $p = .14$, $\eta_p^2 = .012$, and temporal direction, task type and operation span $F(1, 185) = 0.55$, $p = .46$, $\eta_p^2 = .003$. There was a significant two-way interaction between temporal direction and task type $F(1, 185) = 6.46$, $p < .05$, $\eta_p^2 = .034$. Pairwise comparisons revealed that participants rated less auditory imagery for past events in the dual-task condition ($M = 4.68$, $SD = .14$) compared to the single-task condition ($M = 5.31$, $SD = .11$); $p < .001$, %95 C.I. = [-.92, -.34]). Additionally, in the single-task condition, future events ($M = 4.98$, $SD = .12$) were experienced with lower auditory imagery than past events ($M = 5.31$, $SD = .12$); $p < .05$, %95 C.I. = [-.92, -34].

The remaining two-way interactions were not significant; task type and group $F(1, 185) = 0.39$, $p = .53$, $\eta_p^2 = .002$, task type and operation span $F(1, 185) = 0.85$, $p = .36$, $\eta_p^2 = .005$, temporal direction and group $F(1, 185) = 0.12$, $p = .73$, $\eta_p^2 = .001$, and temporal direction and operation span $F(1, 185) = 0.31$, $p = .58$, $\eta_p^2 = .002$. The main effect of task type was significant $F(1, 185) = 14.24$, $p < .001$, $\eta_p^2 = .072$. Accordingly, the participants rated less auditory imagery for the events they remembered/imagined in the dual-task condition (*M* = 4.77, *SD* = .12) than in the single-task condition (*M* = 5.15, *SD* = .10). The main effect of temporal direction was not significant $F(1, 185) = 0.73$, $p = .39$, $\eta_p^2 = .004$.

Taken together, these results suggest that participants experienced events with less auditory details in the dual-task condition compared to the single-task condition (Fig. 3). This difference was more pronounced when participants engaged in the past remembering task, indicating that individuals experienced fewer auditory details in their past events during dual-tasking compared to single-tasking. Furthermore, comparisons within the single-task condition revealed that future events were experienced with lower auditory details than past events.

Figure 4. Illustration of differences in auditory imagery of past and future events between single and dual-task conditions.



* $p < .05$; *** $p < .001$

3.2.2.5. Spatial Imagery

The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 185) = 0.80$, $p = .37$, $\eta_p^2 = .004$. The three-way interaction between temporal direction, task type and operation span was also not significant $F(1, 185) = 0.02$, $p = .97$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 185) = 0.50$, $p = .48$, $\eta_p^2 = .003$; task type and group $F(1, 185) = 0.29$, $p = .59$, $\eta_p^2 = .002$, task type and operation span $F(1, 185) = 0.05$, $p = .83$,

η_p^2 = .000, temporal direction and group $F(1, 185) = 0.22$, $p = .64$, η_p^2 = .001, temporal direction and operation span $F(1, 185) = 0.27$, $p = .60$, η_p^2 = .001. The main effect of task type was significant $F(1, 185) = 12.03$, $p = .001$, η_p^2 = .061. The participants rated less spatial imagery for the events they remembered/imagined in the dual-task condition (M = 5.16, SD = .09) than in the single-task condition (M = 5.51, SD = .08). The main effect of temporal direction was also significant $F(1, 185) = 9.92$, $p < .01$, η_p^2 = .051. Accordingly, future events (M = 5.17, SD = .09) were rated with less spatial imagery than past events (M = 5.50, SD = .08). These results indicate that participants experienced events with less spatial imagery during dual-tasking compared to single-tasking. Furthermore, future events contained less spatial imagery than past events.

3.2.2.6. Valence

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 0.09$, $p = .77$, η_p^2 = .000, and temporal direction, task type and operation span $F(1, 185) = 1.17$, $p = .19$, η_p^2 = .009. Two-way interactions were also not significant; temporal direction and task type $F($ (1, 185) = 0.41, $p = .52$, η_p^2 = .002, task type and group $F(1, 79) = 0.41$, $p = .52$, η_p^2 = .002, task type and operation span $F(1, 185) = 0.06$, $p = .80$, η_p^2 = .000, temporal direction and group $F(1, 185) = 2.45$, p = .12, η_p^2 = .013, and temporal direction and operation span $F(1, 185) = 0.07$, $p = .79$, η_p^2 = .000. There was a main effect of temporal direction $F(1, 185) = 11.63$, $p = .001$, η_p^2 = .059. Accordingly, the participants rated the future events (M = 4.98, SD = .09) more positively than the past events (M = 4.52, SD = .11). The main effect of task type was not significant $F(1, 185) = 0.94$ $p = .33$, η_p^2 = .005. It appears that future events were experienced more positively than past events, regardless of task type and group (visual/verbal).

3.2.2.7. Emotional Intensity

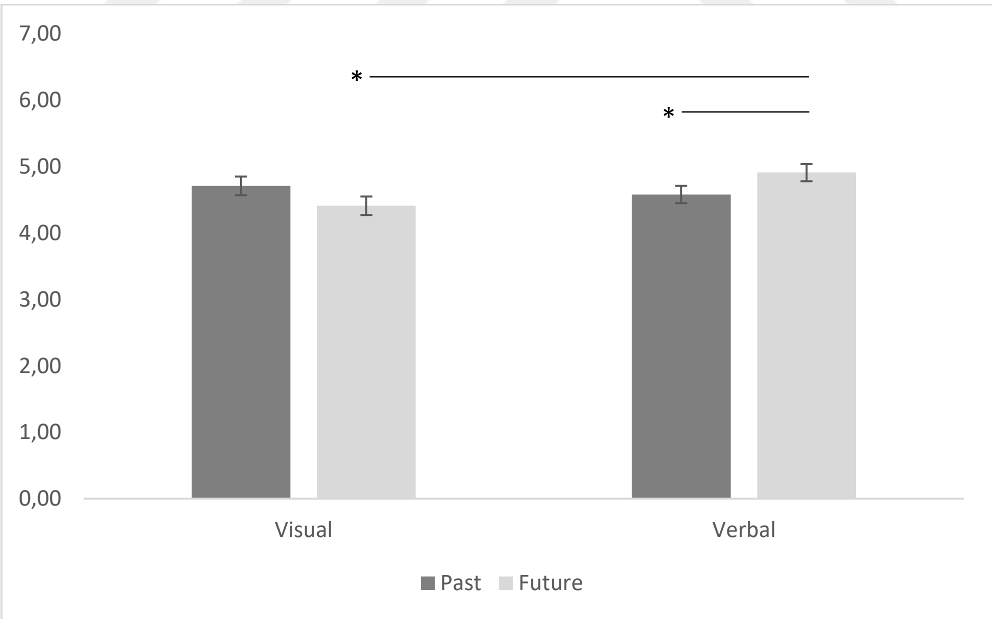
The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 185) = 0.55$, $p = .46$, η_p^2 = .003. The three-way interaction of temporal direction, task type and operation span task was also non-significant $F(1, 185) = 0.09$, $p = .92$, η_p^2 = .000. There was a significant two-way interaction between temporal direction and group $F(1, 185) = 7.73$, $p < .01$, η_p^2 = .040. Pairwise comparisons revealed a significant group difference, suggesting that the visual group (M = 4.41, SD = .14) rated less intensity than the verbal group (M = 4.91, SD = .13) for future events

($p < .05$, %95 C.I. = [-.868, -.121]). Additionally, past events ($M = 4.58$, $SD = .13$) rated with less intensity compared to future events ($M = 4.90$, $SD = .13$) in the verbal group ($p < .05$, %95 C.I. = [-.627, -.023]).

There were no other two-way interactions; temporal direction and task type $F(1, 185) = 0.77$, $p = .78$, $\eta_p^2 = .000$, task type and group $F(1, 185) = 0.52$, $p = .47$, $\eta_p^2 = .003$, task type and operation span $F(1, 185) = 0.23$, $p = .64$, $\eta_p^2 = .001$, temporal direction and operation span $F(1, 185) = 0.05$, $p = .83$, $\eta_p^2 = .000$. The main effect of temporal direction $F(1, 185) = 0.02$, $p = .89$, $\eta_p^2 = .000$, and task type $F(1, 185) = 2.08$, $p = .15$, $\eta_p^2 = .011$ were also not significant.

The findings suggest that future events were experienced with less emotional intensity in the visual group compared to the verbal group (Fig. 4). Conversely, in the verbal group, past events were experienced with less emotional intensity compared to future events.

Figure 5. Interaction between temporal direction and group in terms of emotional intensity.



* $p < .05$; *** $p < .001$

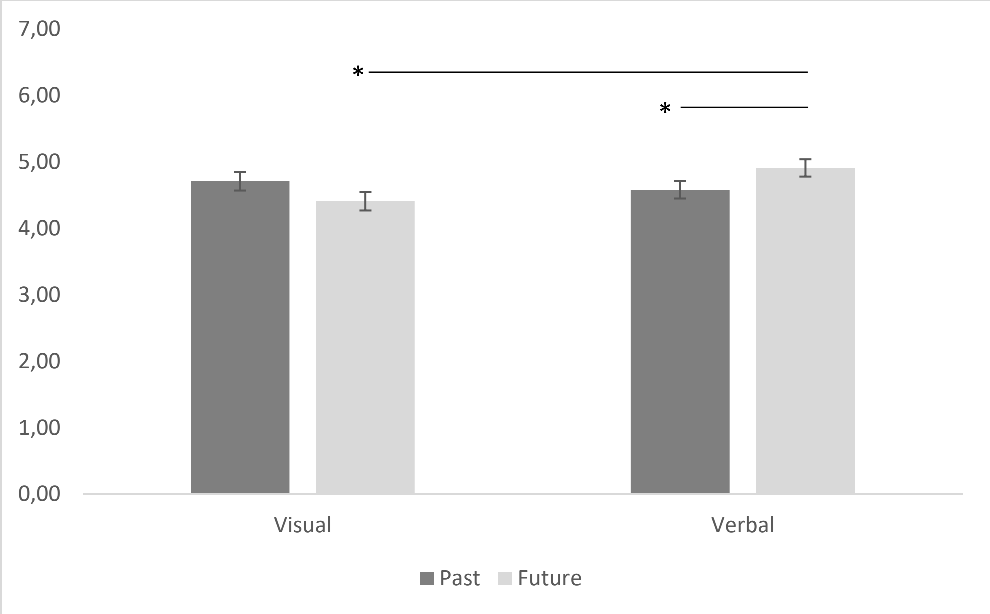
3.2.2.8. Personal Importance

The analysis results revealed no three-way interaction both between temporal direction, task type, and operation span $F(1, 185) = 0.65$, $p = .80$, $\eta_p^2 = .000$, as well as between temporal direction, task type, and group $F(1, 185) = 0.85$, $p = .36$, $\eta_p^2 = .005$. There was a two-way interaction between temporal direction and group $F(1, 185) = 7.34$, $p < .01$, $\eta_p^2 = .038$. Pairwise comparisons showed that, past events ($M = 3.82$, $SD = .15$) were rated as less personally important than future events ($M = 4.37$, $SD = .15$) in the verbal group ($p < .05$, %95 C.I. = [-.908, -.202]), but not in the visual group. Moreover, future events were rated as less important in the visual group ($M = 3.79$, $SD = .15$) than in the verbal group ($M = 4.37$, $SD = .15$); $p < .05$, %95 C.I. = -.1.007, -.166].

There were no other two-way interactions; the interaction between temporal direction and task type $F(1, 185) = 1.52$, $p = .22$, $\eta_p^2 = .008$, task type and group F(1, 185) = 0.27, $p = .61$, $\eta_p^2 = .001$, task type and operation span $F(1, 185) = 0.03$, $p = .86$, $\eta_p^2 = .000$, and temporal direction and operation span $F(1, 185) = 0.40$, $p = .53$, $\eta_p^2 = .002$. The main effect of task type was significant $F(1, 185) = 7.39$, $p < .01$, $\eta_p^2 = .038$. The events were rated as less important in the dual-task condition ($M = 3.79$, $SD = .11$) than in the single-task condition ($M = 4.17$, $SD = .11$). Lastly, the main effect of temporal direction was not significant $F(1, 185) = 2.43$, $p = .12$, $\eta_p^2 = .013$.

These results suggest that past events were rated as less personally important than future events in the verbal group. Additionally, future events were perceived as less important in the visual group compared to the verbal group (Fig. 5). Lastly, the events were rated as less important in the dual-task condition compared to the single-task condition, regardless of their temporal direction.

Figure 6. Differences in personal importance of events between visual and verbal groups.



* *p* < .05; *** *p* < .001

3.2.2.9. Ease of Imagining/Remembering

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 0.02$, $p = .88$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 185) = 0.08$, $p = .78$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 185) = 0.55$, $p = .46$, $\eta_p^2 = .003$, task type and group $F(1, 185) = 2.26$, $p = .13$, $\eta_p^2 = .028$, task type and operation span $F(1, 185) = 0.15$, $p = .70$, $\eta_p^2 = .001$, temporal direction and group $F(1, 185) = 0.44$, $p = .51$, $\eta_p^2 = .002$, and temporal direction and operation span $F(1, 185) = 0.25$, $p = .62$, $\eta_p^2 = .001$. There was a main effect of task type $F(1, 185) = 23.04$, $p < .001$, $\eta_p^2 = .111$. Pairwise comparisons revealed that participants found it more difficult to remember/imagine events in the dual-task condition ($M = 5.22$, $SD = .10$) than in the single-task condition ($M = 5.70$, $SD = .07$). The main effect of temporal direction was not significant $F(1, 185) = 0.47$, $p = .83$, $\eta_p^2 = .000$.

3.2.2.10. Specificity

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 1.48$ $p = .23$, $\eta_p^2 = .008$, and temporal direction, task type and operation span $F(1, 185) = 3.29$, $p = .07$, $\eta_p^2 = .017$. Two-way interactions were also not significant; temporal direction and task type $F(1, 185) = 1.01$, $p = .32$, $\eta_p^2 = .005$, task type and group $F(1, 185) = 0.08$, $p = .76$, $\eta_p^2 = .000$, task type and operation span $F(1, 185) = 0.73$, $p = .39$, $\eta_p^2 = .004$, temporal direction and group $F(1, 185) = 0.89$, $p = .35$, $\eta_p^2 = .005$, and temporal direction and operation span $F(1, 185) = 0.36$, $p = .55$, $\eta_p^2 = .002$. The main effect of temporal direction was significant $F(1, 185) = 6.28$, $p < .05$, $\eta_p^2 = .033$. The specificity of future events ($M = 5.71$, $SD = .09$) was lesser than that of past events ($M = 5.97$, $SD = .09$). The main effect of task type was not significant $F(1, 185) = 0.64$, $p = .43$, $\eta_p^2 = .003$.

3.2.2.11. Imagery Perspective

No three-way interaction were observed both between temporal direction, task type, and operation span $F(1, 184) = 0.61$, $p = .44$, $\eta_p^2 = .003$, and between temporal direction, task type, and group $F(1, 184) = 0.02$, $p = .90$, $\eta_p^2 = .000$. Two-way interactions were also not significant; the interaction between temporal direction and task type $F(1, 184) = 1.65$, $p = .20$, $\eta_p^2 = .009$, task type and group $F(1, 184) = 0.38$, $p = .54$, $\eta_p^2 = .002$, task type and operation span $F(1, 184) = 0.35$, $p = .55$, $\eta_p^2 = .002$, temporal direction and group $F(1, 184) = 0.26$, $p = .61$, $\eta_p^2 = .001$, and temporal direction and operation span $F(1, 184) = 0.01$, $p = .97$, $\eta_p^2 = .000$. The main effects were also not significant for both temporal direction $F(1, 184) = 0.76$, $p = .39$, $\eta_p^2 = .004$ and task type $F(1, 184) = 2.58$, $p = .11$, $\eta_p^2 = .014$.

3.2.2.12. Voluntary Rehearsal

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 185) = 0.01$, $p = .93$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 185) = 0.03$, $p = .86$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 185) = 2.16$, $p = .14$, $\eta_p^2 = .012$, task type and group $F(1, 185) = 0.04$, $p = .85$, $\eta_p^2 = .000$, task type and operation span $F(1, 185) = 0.25$, $p = .62$, $\eta_p^2 = .016$, temporal direction and group $F(1, 185) = 2.98$, $p = .52$, $\eta_p^2 = .005$, and temporal direction and operation span $F(1, 185) = 0.95$, $p = .09$, $\eta_p^2 = .016$. The main effects were also not significant; task type $F(1, 185) = 3.09$, $p = .08$, $\eta_p^2 = .016$, temporal direction $F(1, 185) = 0.30$, $p = .86$, $\eta_p^2 = .000$.

3.2.2.13. Involuntary Rehearsal

The analysis showed no three-way interaction of temporal direction, task type and group $F(1, 185) = 3.53$, $p = .06$, $\eta_p^2 = .019$. The three-way interaction of temporal direction, task type and operation span was also not significant $F(1, 185) = 0.73$, $p =$

.40, η_p^2 = .004. Two-way interactions were not significant; the interaction between temporal direction and task type $F(1, 79) = 2.60$ $p = .11$, η_p^2 = .014, task type and group F(1, 185) = 0.04, $p = .85$, η_p^2 = .000, task type and operation span $F(1, 185) = 0.04$, $p = .85$, η_p^2 = .000, temporal direction and group $F(1, 185) = 2.78$, $p = .10$, η_p^2 = .015, and temporal direction and operation span $F(1, 185) = 0.19$, $p = .67$, η_p^2 = .001. The main effect of task type $F(1, 185) = 0.14$, $p = .70$, η_p^2 = .001, and direction $F(1, 185) = 0.84$, $p = .36$, η_p^2 = .005 were also not significant

3.3. Further Analyses

3.3.1. 2-back Reaction Time

A mixed ANOVA was conducted to compare reaction times to 2-back stimuli in single and dual-task conditions (averaged across temporal direction) between groups (verbal/visual) to investigate whether there are differences between groups in terms of reaction times for the secondary task and to further explore the dual-task cost on reaction time for the secondary task. The descriptive statistics are shown (Table 4). The two-way interaction of task type and group was significant $F(1, 181) = 10.61$, $p = .001$, η_p^2 = .055. Pairwise comparisons showed that reaction time to verbal 2-back stimuli was higher than visual stimuli in both single-task ($p < .001$, %95 C.I. = [94.79, 269.99]); and dual-task conditions ($p < .001$, %95 C.I. = [267.43, 442.59]). Furthermore, in the verbal group, the reaction time was higher in the dual-task condition than in the single-task condition ($p < .01$, %95 C.I. = [29.86, 174.05]), but not in the visual group. The main effect of task type was not significant $F(1, 181) = 0.35$, $p = .55$, η_p^2 = .002.

Table 3. Descriptive statistics of reaction times.

Reaction times (to hits only)				
Conditions	Groups	*M*	*SD*	*N*
Single-task	Visual	771.2	312.6	87
	Verbal	953.5	287.9	96
	Total	866.8	312.7	183

	Visual	700.5	242.4	87
Dual-task	Verbal	1055.5	343.7	96
	Total	886.7	347.9	183

3.3.2. 2-back Accuracy

A mixed ANOVA was conducted to compare accuracies of 2-back stimuli in single and dual-task conditions (averaged across temporal direction) between groups (verbal/visual) to investigate whether there are differences between groups in terms of accuracies for the secondary task and to further explore the dual-task cost on accuracies for the secondary task. D-prime (*d*′) scores were calculated for the trials. The descriptive statistics are shown (Table 5). There was a significant two-way interaction between task type and group $F(1, 181) = 9.98$, $p = .002$, $\eta_p^2 = .052$. Pairwise comparisons revealed that the visual group's accuracy was lower than verbal group's accuracy in the single-task condition, but not in the dual-task condition ($p < .001$, %95 C.I. = [-.846, -.258]). Moreover, the accuracy of the verbal 2-back task in the dual-task condition was lower than in the single-task condition ($p < .001$, %95 C.I. = [-.709, -.259]), but not for the visual 2-back task. The main effect of task type was also significant $F(1, 181) = 7.31$, $p < .01$, $\eta_p^2 = .039$. The accuracy in the dual-task condition was lower than in the single-task condition ($p < .01$, %95 C.I. = [-.386, -.060]).

Table 4. Descriptive statistics of accuracies.

Accuracy (*d*′)				
Conditions	Groups	*M*	*SD*	*N*
	Visual	2.66	1.14	87
Single-task	Verbal	3.21	.87	96
	Total	2.95	1.04	183

	Visual	2.70	.88	87
Dual-task	Verbal	2.73	.66	96
	Total	2.71	.77	183

Taken together, these findings indicate that people spend more time reacting to auditory stimuli than visual stimuli, in both single and dual-task conditions. It is often assumed that accuracy decreases as reaction time increases in n-back tasks, especially with the increase of task difficulty (Meule, 2017). Interestingly, only the verbal 2-back task showed increased reaction time and decreased accuracy in the dual-task condition compared to the single-task condition. One might argue that the verbal working memory task used in this study is more cognitively demanding than the visual working memory task. This may be inferred from the longer reaction time for verbal stimuli compared to visual stimuli in the single-task condition and the sensitivity of verbal stimuli to the cognitive load of dual-tasking. However, in our study, although verbal 2-back task showed higher reaction time in the single-task condition, we also observed lower accuracy for visual 2-back task than verbal 2-back in the same condition. This reversed pattern may stem from differential correlates of these measures (Meule, 2017). For instance, Jaeggi et al. (2010) found that fluid intelligence was correlated with the accuracy of visuospatial and verbal n-back tasks, but not with reaction time. Additionally, in the visuospatial n-back task, reaction time positively correlated with forward digit and reading span scores, but not with accuracy. Therefore, the cognitive processes involved in determining reaction time and accuracy performances in verbal and visual 2-back tasks most likely be utilized differently. To uncover this reversed pattern observed in our study, the correlations were examined between operation span score and reaction time and accuracy in the single-task condition. The analysis showed a positive correlation between operation span and accuracy in the single-task condition $r(188) = .19, p < .01$, and in the dual-task condition $r(181) = .16, p < .05$, but operation span did not correlate with any reaction time measures. It appears that working memory capacity is linked to the accuracy of 2-back tasks regardless of the task condition, whereas it does not correlate with reaction times. Therefore, it is difficult to conclude whether there is a cognitive load difference between visual and verbal 2-back tasks, as these measures exhibited reverse patterns, which might be influenced by several factors[7].

CHAPTER IV

4. Discussion

The aim of this study was to investigate whether visual and verbal components of working memory contribute differently to episodic future thinking and whether component utilization differs across temporal directions while controlling the effects of working memory capacity. To this end, we conducted an experiment using a novel dual-task paradigm. Participants were asked to remember a personal past event or imagine a personal future event (primary tasks), while simultaneously performing either visual or verbal 2-back tasks (secondary tasks), in single and dual-task conditions. We analyzed the reaction times for event constructions during the 2-back tasks, as well as the phenomenological ratings of the events remembered/imagined during dual-tasking.

Our discussion will begin with the comparison of remembering past and imagining future events, delving into constructive episodic simulation hypothesis. Subsequently, we will investigate the effect of general cognitive load on remembering/imagining events. We will discuss the effects of dual-tasking on past and future events, probing the impact of cognitive load on both episodic future thinking and episodic memory. Firstly, we will argue the underlying reasons as to why cognitive load did not diminish the constructions of those events. Then, the effect of dual-task cost will be discussed at the subjective level, explaining the detrimental impact of cognitive load on the phenomenology of episodic future thinking and episodic memory. Subsequently, we will delve into the differences between episodic future thinking and episodic memory, and probe the effects of modality-specific (visual and verbal) cognitive load on these events. We will discuss the differences between these temporal directions in terms of

[7] The number of correct trials in the single (4 targets) and dual-task conditions (2 targets) was also insufficient to draw conclusions regarding significant differences in reaction times and accuracies between these tasks as the variance is relatively narrow.

phenomenological experiences, followed by a comparison of the constructions of these events.

Remembering Past and Imagining Future Events

We expected that constructing future events would be a slower process than remembering past events, as these future events require the flexible recombination of episodic details stored in episodic memory, which results in additional cognitive demand. Our findings supported this prediction, revealing that constructing a future event took more time than remembering a past event. These results are in line with the constructive episodic simulation hypothesis, suggesting that future thinking taxes more cognitive resources and requires more relational processing than past remembering (Addis & Schacter, 2007; Roberts, Schacter & Addis, 2016; Anderson, Dewhurst & Nash, 2012; Wiebels et al., 2020; El Haj & Lenoble, 2018; Zavagnin et al., 2016; Arnold, McDermott, & Szpunar, 2011). It appears likely that constructing future events necessitates inhibiting a wide range of unnecessary information arrays, since these events can be created from any combination of this array, resulting in additional cognitive demand compared to remembering the past, which only requires retrieving a specific combination of information. Moreover, our results revealed that imagining future events was perceived as less pre-experienced compared to past events. Interestingly, this pattern was more pronounced among the participants with lower working memory capacity, revealing that these participants felt less pre-experience for future events compared to past events. It seems that episodic future thinking places demands on cognitive resources associated with working memory capacity, and lower levels of working memory capacity may limit individuals' feeling of pre-experiencing future-oriented events more than re-experiencing past events. Furthermore, we also found that future events were rated as less specific than past events. This finding dovetails with studies showing poorer specificity for future events compared to past events (Özbek et al., 2017; Anderson & Dewhurst, 2009; Addis et al., 2008). Although a decline in working memory is an indicator of poor specificity of both past and future events (Addis et al., 2008; Addis et al., 2010; Gaesser et al., 2011; Cole et al., 2013; Zavagnin et al., 2016; Piolino et al., 2010), it appears that future thinking requires more relational processing and more executive functioning than past remembering, and thus contains fewer details than past events. This difference in specificity appears to be more nuanced in spatial details, as future events were experienced with less spatial imagery. This finding is in alignment with the studies that demonstrate fewer sensory details for future events than past events (D'Argembeau & Van der Linden, 2004; Addis et al., 2008; Berntsen & Bohn, 2010). The constructive demand of future thinking, therefore, might impede individuals' capacity to create specific future events compared to past events, thus results in poor sensory details and less pre-experience.

We also observed that future events were rated as more positively valenced than past events. This pattern points to the well-known phenomenon of positivity bias in future thinking (Salgado & Berntsen, 2019; D'Argembeau & Van Der Linden, 2004). People tend to perceive the future more positively than the past, possibly due to the self-enhancement function of imagining positive events or the ease of finding a positive event from the future. D'Argembeau and Linden (2004) showed that participants could easily access positive future events rather than negative ones, allowing them to create a clear and rich representation of the future in an experimental setting. Therefore, in our experiment, which requires considerable cognitive demand, participants may have been inclined to imagine a positive future event as it would be easier than imagining negative future events.

Constructing Past and Future Events Under Cognitive Load

We initially expected to find a detrimental effect of cognitive load on constructing past and future events, assuming that the load would tax cognitive resources and make it difficult to construct an event. Surprisingly, the participants were faster at constructing events under cognitive load (dual-task) than in the absence of cognitive load (single-task). At first glance, one would expect an increase in reaction time latency in constructing events under cognitive load, as that load would compete with constructing events for cognitive resources. However, this impairment can be mitigated after single-task practices, due to the phenomenon called dual-task practice advantage (DTPA) (Strobach & Schubert, 2016; Strobach, 2020). Numerous studies have shown a practice-related reduction in dual-task cost (please see for a detailed review Strobach & Schubert, 2016; Strobach, 2020). For example, Schumacher et al. (2001) observed longer reaction time latency during single-task phases compared to dual-task phases, implying that extended practice leads to reduced dual-task costs through optimization of time-sharing between tasks (please see Strobach & Schubert, 2016; Tombu & Jolicoeur, 2004). In our experiment, the participants first completed the single-tasks (including practice and experimental stages) which may have contributed to their familiarity with the primary task. Therefore, the decreased reaction time in the dual-task conditions could be attributed to this familiarity, as the participants had already constructed events four times during the single-task stages before performing the dual-tasks. Since the participants were unfamiliar with the experiment at the beginning, their single-task performance might have been worse than their dual-task performance. However, we observed the DTPA only in the reaction time data. The events remembered/imagined under cognitive load were impaired in their phenomenological experiences due to this load. These events were characterized by a lesser sense of pre/re-experience, less vivid and poorer visual, spatial, and auditory imagery, and were perceived as less important and more difficult to remember or imagine. Below, we discuss the impact of cognitive load on the phenomenology of remembering past events and imagining future events in more detail.

Phenomenological Experiences Under Cognitive Load

We expected cognitive load to impair the phenomenological experiences of the events due to the competition for cognitive resources. The findings revealed that cognitive load has a detrimental impact on vividness, pre/re-experiencing, visual imagery, auditory imagery, spatial imagery, personal importance, and ease of remembering/imagining. It appears that cognitive load diminishes the subjective feeling of remembering/imagining events, making these events more difficult to mentalize. These results contradict with the study of Anthony et al. (2023), which showed that dual-task cost did not affect the phenomenology of autobiographical memories. In their study, the participants recalled memories simultaneously under three different conditions: tracking a moving dot, watching dynamic visual noise (DVN), and looking at a blank screen as a control condition. Once an event come up the participants' mind, they pressed a specified button, and described their memories. One important point is that the secondary tasks were only presented during the retrieval phase. Thus, the participants did not attend a secondary task after they indicated the event was found. The authors explained these results, suggesting that the cost of the secondary task on phenomenological features was reduced because participants had sufficient time to elaborate on the event in the absence of the secondary task. In our study, we had our participants perform two tasks simultaneously and asked them to elaborate on the events while engaging in the secondary task, thus better capturing the effect of the secondary task on imagining/remembering events.

Interestingly, we found that higher levels of working memory capacity were not sufficient to alleviate the cognitive load of dual-tasking on future thinking. Participants with higher working memory capacity rated these events as less pre-experienced under cognitive load compared to when there was no cognitive load. This may point out the need for additional cognitive resources on top of working memory capacity to pre-experience future events, such as visuospatial information processing. For example, in a study employing a similar procedure we used in our study (de Vito et al., 2015), the participants had to perform three types of secondary tasks (focusing on a moving dot, hand tapping, and free viewing) while concurrently performing episodic future thinking or episodic memory tasks. The participants were asked to recount these events while engaging the secondary tasks. Their results indicated that voluntary eye movements disrupt the episodic future thinking in imagining details about events, places, and emotions, but had no effect on episodic memories. Since hand-tapping task did not affect the phenomenology of those events, it can be inferred that performing voluntary eye movements disrupt the phenomenological quality of future events. This result can be explained by the resource competition between voluntary eye movements and visuospatial information processing (de Vito et al., 2014; Postle et al., 2006). It appears that future thinking relies on visuospatial information processing and is thus disrupted by visuospatial cognitive load, indicating that working memory capacity alone is not sufficient.

Constructing Past and Future Events Under Modality-Specific Cognitive Load

Our main hypothesis was imagining future events while performing a visual working memory task would result in higher reaction times compared to performing a verbal working memory task. However, our results contradict with this hypothesis, showing that modality-specific cognitive load did not affect the construction of future events differently. The other anticipation was that visual working memory task would interfere with constructing future events more than past events, leading to a higher reaction times. However, we also did not observe any difference between constructing past and future events under visual working memory load. Interestingly, our results showed a greater reaction time latency for constructing future events compared to recalling past events while performing a verbal working memory task. This finding points out the role of verbal information processing during future event construction and is in alignment with the studies' findings demonstrating this connection in preschoolers (Ferretti et al. 2017; Atance et al., 2019; Cuevas, Rajan, Morasch & Bell, 2015; Naito & Suzuki, 2011). In this regard, our findings represent the first evidence of the involvement of verbal working memory in episodic future thinking within a younger adult sample, as compared to episodic memory. One possible, but unlikely, explanation for this result could have emerged due to our experimental paradigm itself. In this paradigm, participants were asked to promptly provide at least three or two words after pressing the specified key to indicate an event that came to their mind, aloud. Before orally reporting it, the load on verbal working memory may have interfered with the production of spoken reports. However, this explanation raises the question of why this pattern was only observed in the combination of future thinking and verbal working memory tasks, as we found no evidence of differences between visual and verbal, or episodic memory and verbal working memory combinations. Therefore, additional explanations are needed.

The other explanation would be the semantic organization of the future events. Studies suggest that semantic knowledge is crucial for creating future events, as it provides a scaffold within which episodic details can be organized to generate novel, specific future events (Irish et al., 2012). This semantic scaffolding appears to be more important for future events compared to past events. For example, individuals with semantic dementia, which is characterized by severe impairments in semantic knowledge, can construct past events better than future events. Therefore, performing the verbal working memory task while trying to construct a future event might have interfered with the semantic organization of the event before reporting it, as the participants first had to organize general personal knowledge to construct a specific future event (D'argembeau & Mathy, 2011). Thus, it is possible that the verbal working memory task disrupted the semantic organization of future events more than past events, where semantic relations were already established.

Since we did not find any difference between visual and verbal working memory load in constructing future events, the most probable explanation for that result would stem from the connection between visual working memory and past remembering. Our findings indicate that remembering past events while performing a visual working memory task is a lengthier process than performing a verbal working memory task. This finding is in line with the studies showing the crucial role of visual working memory during past remembering (Brewer, 1988; Conway, 2009; Rubin, Schrauf & Greenberg, 2003; Rubin, 2005; 2006; Gatti et al. 2022; Anderson et al., 2017; Sheldon et al., 2019). Rubin and colleagues (2003) showed that the more vivid the visual information in a particular memory, the stronger the episodic recall, which involves the feeling of reliving that moment by returning to a specific moment in the past. The studies employing dual-task paradigms also demonstrated the role of visual working memory in past remembering, indicating that visual cognitive load made it difficult to come up with a past event (Gatti et al., 2022; Anderson et al., 2017; Sheldon et al., 2019; Anthony et al., 2023). Therefore, our findings are in alignment with the literature, and demonstrate the important role of visual working memory in constructing past events. The importance of visual working memory in constructing past events may explain why we observed differences between past and future events under verbal working memory load. It is likely that the construction of past events was not affected by verbal working memory load to the same extent as it was for future events, highlighting the distinct role of visual working memory in constructing past events. Therefore, the explanation for why verbal working memory load interferes more with future events than with past events may lie in this distinct role, rather than in the distinct role of verbal working memory in constructing future events. Ultimately, working memory components seemed to contribute to constructing future events to a similar extent, but visual working memory is more heavily utilized during past event construction.

Phenomenological Experiences Under Modality-Specific Cognitive Load

Our main hypothesis was imagining future events while performing a visual working memory task would result in poorer phenomenological evaluations compared to performing a verbal working memory task. We supported this hypothesis, showing that visual working memory load disrupts the emotional intensity and personal importance of future events to a greater extent than verbal working memory load. D'Argembeau and Linden (2006) showed that people who have more vivid visual imagery pre-experience future events more vividly and intensely than those who have less visual imagery. This connection may stem from the utilization of visual working memory during the regulation of emotional intensity of future events, as processing visual information may interfere with the emotional intensity of those events, according to our results. The literature also suggest that personal importance is one of the most important predictors of pre-experiencing future events, leading to a stronger autonoetic experience for episodic future thinking (i.e. subjective feeling of mental time travelling through time) for those events (Lehner & D'argembeau, 2016; D'argembeau & van der Linden, 2012; Barsics et al., 2015). In our study, we found that visual working memory load impedes the personal importance of future events to a greater extent than verbal working memory load. Given the strong connection between personal importance and autonoetic consciousness, this result may imply that visual working memory load has a detrimental impact on mental time travel to the future.

We also anticipated that visual working memory load would disrupt phenomenological experiences of episodic future thinking more than episodic memory. We did not find any evidence to support this hypothesis, but revealed that remembering the past and imagining the future utilize verbal working memory component differently. The findings demonstrated that verbal working memory load interferes more with the emotional intensity and personal importance of past events than future events. These results point out the role of verbal working memory in remembering past events, and supporting the narrative framework of memory (Fivush, Haden & Reese, 2006; Fivush, 2008). For example, language is a way to share memories and allows people to organize reminscences (Fivush, 2008). In this way, individuals form blocks of life stories, creating a narrative of past events (Fivush, 2008). These narratives, therefore, represent culturally shaped linguistic structures that influence how individuals remember their personal events and how they express them (Fivush, Haden & Reese, 2006). Remembering past events may involve verbal information processing more than episodic future thinking, as these past events are likely to be remembered as a narrative. Thus, people might not remember the events themselves, but they do recall their narratives[8]. Considering these points, it appears that verbal working memory load diminishes the emotional intensity and personal importance of these past events more than future events.

The other possibility as to why verbal working memory interfered with phenomenological experiences for past events more than future events stems from the crucial role of visual working memory in episodic future thinking. It is likely that the emotional intensity and personal importance of future events were not affected by the verbal working memory load to the same extent as they were for past events. Therefore, this may imply the distinct role of visual working memory in episodic future thinking. Ultimately, while working memory components appear to contribute to past events to a similar extent, visual working memory is more heavily utilized during future thinking.

4.1. CONCLUSION

Overall, our investigation showed that people utilize both visual and verbal working memory to construct future events. However, visual working memory becomes more crucial when elaborating on these events. Additionally, we demonstrated that individuals use visual working memory when constructing past events, but both visual and verbal working memory contribute to the elaboration of past events.

The literature suggest that working memory is one of the cognitive mechanism that supports episodic future thinking. However, to date, contributions of working memory components to episodic future thinking remained unclear. In this regard, our results are the first to show differential contributions of working memory components to future thinking. Additionally, there has been no attempt to test the constructive episodic simulation hypothesis in this context, comparing the differential contributions of working memory components to both remembering the past and imagining the future. Therefore, our results are also the first to compare these temporal directions in a modality-specific context. We also used a novel dual-task paradigm that can be utilized in future studies to investigate the cognitive mechanisms of episodic future thinking and episodic memory in more detail.

[8] Jorge Luis Borges once said that: "*The years pass and I've told this story so many times I no longer know whether I remember it as it was or whether it's only my words I'm remembering.*" (Borges, 1979, p. 54).

Since we showed the pivotal role of visual working memory in episodic future thinking, this finding may contribute to delay discounting and working memory training literature. Some studies suggest that working memory training can improve the efficiency of episodic future thinking in decision-making processes, such as delay discounting (Bickel et al., 2011; Snider et al., 2018). This facilitatory role of episodic future thinking on delay discounting increases when the events are experienced with greater emotional intensity (Benoit, Gilbert & Burgess, 2011). Since our results point out the important role of visual working memory on the emotional intensity and personal importance of future events, future studies could use visual working memory training and examine the effects of that training on the efficiency of episodic future thinking in decision-making processes. If these trainings are effective, it will enhance the tendency to make decisions that are beneficial for health, such as smoking (Chiou & Wu, 2017; Stein et al., 2018), eating habits (Daniel et al., 2013; Daniel et al., 2015; Dassen et al., 2016; Segovia et al., 2020), or continuing/leaving a hobby that may have positive/negative effects on health (Kaplan et al., 2016).

4.2. Limitations of the Study

Our study has some limitations. For example, the number of trials resulted in an increasing number of missing values. Since the measures were one-shot, failure in a trial led to the exclusion of participants from our statistical model, as three-way interaction analysis required successful completion of all trials. Given that some participants could not recall an event in certain trials, and complete-case analyses would reduce power, we employed the multiple imputation technique. To mitigate this issue, future studies could consider adding extra trials for every measure or providing additional cue words to participants who were failed to construct an event, thus reducing the likelihood of missing data. However, increasing the number of trials could prolong the duration of the experiment, potentially leading to participant fatigue. Therefore, future studies intending to adopt this paradigm should consider providing additional cue words rather than increasing the number trials.

Another limitation was the disproportionate gender distribution in our sample. Our sample consisted predominantly of female participants, and this imbalance may limit the generalizability of our findings. Future studies should aim to recruit participants with a more balanced gender representation. Furthermore, all of the participants were

Bachelor’s students, thus limiting the population of our sample to these students. However, this allowed us to have a homogenous sample, thereby reducing the effects of variables such as age and education.

The visual and verbal versions of the 2-back might have taxed different cognitive resources beyond the respective modality-specific cognitive load, as we found some differences between these tasks. Future studies could also employ different working memory tasks for this investigation (e.g., Corsi block tapping, counting aloud, etc.). Probing the aforementioned findings with different working memory tasks would make these conclusions more reliable and yield some important insights into the role of working memory components on both remembering the past and imagining the future. Furthermore, these tasks could have employed as a within-subject factor, rather than between-subject factor. In this way, individual differences in modality-specific information processing would be eliminated, and thus better capturing the differential contributions of working memory components. Therefore, future studies should take this matter into consideration.

REFERENCES

Addis, D. R., Musicaro, R., Pan, L., & Schacter, D. L. (2010). Episodic simulation of past and future events in older adults: Evidence from an experimental recombination task. *Psychology and Aging*, *25*(2), 369–376.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*(7), 1363–1377.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-Related changes in the episodic simulation of future events. *Psychological Science*, *19*(1), 33–41.

Akdere, S., & İkier, S. (2021). Age-consistent phenomenological experience in remembering the past and imagining the past and the future. *Applied Neuropsychology: Adult*, 1–11.

Anderson, R. J., & Dewhurst, S. A. (2009). Remembering the past and imagining the future: Differences in event specificity of spontaneously generated thought. *Memory*, *17*(4), 367–373.

Anderson, R. J., Dewhurst, S. A., & Dean, G. (2017). Direct and generative retrieval of autobiographical memories: The roles of visual imagery and executive processes. *Consciousness and Cognition*, *49*, 163–171.

Anderson, R. J., Dewhurst, S. A., & Nash, R. A. (2012). Shared cognitive processes underlying past and future thinking: The impact of imagery and concurrent task demands on event specificity. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *38*(2), 356–365.

Anthony, K., Wong, H. K., Lim, A., Sow, F., & Janssen, S. M. J. (2023). Examining the roles of visual imagery and working memory in the retrieval of autobiographical memories using a dual-task paradigm. *Quarterly Journal of Experimental Psychology*.

Arnold, K. M., McDermott, K. B., & Szpunar, K. K. (2011). Imagining the near and far future: The role of location familiarity. *Memory & Cognition*, *39*(6), 954–967.

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539.

Atance, C. M., Celebi, S., Mitchinson, S., & Mahy, C. E. V. (2019). Thinking about the future: Comparing children's forced-choice versus "generative" responses in the "spoon test." *Journal of Experimental Child Psychology*, *181*, 1–16.

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences*, *4*(11), 417–423.

Baddeley, A., & Hitch, G. J. (1974). Working memory. In *Psychology of Learning and Motivation* (pp. 47–89).

Bahri, M., & Bahri, M. (2018). Comparison of Episodic Future Thinking and Working Memory in Adolescents With Internalizing Problems and Non-clinical Adolescents. *Journal of Practice in Clinical Psychology*, *6*(3), 183-190.

Barsics, C., Van Der Linden, M., & D'Argembeau, A. (2016). Frequency, characteristics, and perceived functions of emotional future thinking in daily life. *The Quarterly Journal of Experimental Psychology*, *69*(2), 217–233.

Benoit, R. G., & Schacter, D. L. (2015). Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. *Neuropsychologia*, *75*, 450–457.

Benoit, R. G., Gilbert, S. J., & Burgess, P. W. (2011). A neural mechanism mediating the impact of episodic prospection on farsighted decisions.The Journal of Neuroscience, *31*(18), 6771–6779.

Berntsen, D., & Bohn, A. (2010). Remembering and forecasting: The relation between autobiographical memory and episodic future thinking. Memory & Cognition, 38(3), 265–278.

Bertossi, E., Tesini, C., Cappelli, A., & Ciaramelli, E. (2016). Ventromedial prefrontal damage causes a pervasive impairment of episodic memory and future thinking. *Neuropsychologia*, *90*, 12–24.

Bickel, W. K., Stein, J. S., Paluch, R. A., Mellis, A. M., Athamneh, L. N., Quattrin, T., Greenawald, M. H., Bree, K. A., Gatchalian, K. M., Mastrandrea, L. D., & Epstein, L. H. (2020). Does episodic future thinking repair immediacy bias at home and in the laboratory in patients with prediabetes? *Psychosomatic Medicine*, *82*(7), 699–707.

Bickel, W. K., Yi, R., Landes, R. D., Hill, P. F., & Baxter, C. (2011). Remember the future: working memory training decreases delay discounting among stimulant addicts. *Biological Psychiatry*, *69*(3), 260–265.

Borges, J. L. (1975). *The Book of Sand.* Penguin Books.

Breeden, P., Dere, D., Zlomuzica, A., & Dere, E. (2016). The mental time travel continuum: on the architecture, capacity, versatility and extension of the mental bridge into the past and future. *Reviews in the Neurosciences*, *27*(4), 421–434.

Brewer, W. F. (1988). Memory for randomly sampled autobiographical events. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 21–90). Cambridge University Press.

Chiou, W., & Wu, W. (2017). Episodic future thinking involving the nonsmoking self can induce lower discounting and cigarette consumption. *Journal of Studies on Alcohol and Drugs*, *78*(1), 106–112.

Choi, H., Geden, M., & Feng, J. (2017). More visual mind wandering occurrence during visual task performance: Modality of the concurrent task affects how the mind wanders. *PloS One*, *12*(12).

Cocchini, G., Logie, R. H., Della Sala, S., MacPherson, S. E., & Baddeley, A. (2002). Concurrent performance of two memory tasks: Evidence for domain-specific working memory systems. *Memory & Cognition*, *30*(7), 1086–1095.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Erlbaum.

Cole, S. N., Morrison, C. M., & Conway, M. A. (2013). Episodic Future Thinking: Linking Neuropsychological Performance with Episodic Detail in Young and Old Adults. *The Quarterly Journal of Experimental Psychology*, *66*(9), 1687–1706.

Cole, S. N., Morrison, C. M., Barak, O., Pauly-Takacs, K., & Conway, M. A. (2015). Amnesia and future thinking: Exploring the role of memory in the quantity and quality of episodic future thoughts. *British Journal of Clinical Psychology*, *55*(2), 206–224.

Conti, F., & Irish, M. (2021). Harnessing visual imagery and oculomotor behaviour to understand prospection. *Trends in Cognitive Sciences*, *25*(4), 272–283.

Conway, M. (2003). Commentary Cognitive-affective mechanisms and processes in autobiographical memory. *Memory*, *11*(2), 217–224.

Conway, M. A. (2009). Episodic memories. *Neuropsychologia*, *47*(11), 2305–2313.

Coste, C., Navarro, B., Vallat-Azouvi, C., Brami, M., Azouvi, P., & Piolino, P. (2015). Disruption of temporally extended self-memory system following traumatic brain injury. *Neuropsychologia*, *71*, 133–145.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. *Psychological Bulletin*, *104*(2), 163–191.

Cowan, N., Morey, C. C., & Naveh-Benjamin, M. (2021). An embedded-processes approach to working memory: How is it distinct from other approaches, and to what ends? In R. H. Logie, V. Camos, & N. Cowan (Eds.), *Working memory: State of the science* (pp. 44–84). Oxford University Press.

Cuevas, K., Rajan, V., Morasch, K. C., & Bell, M. A. (2015). Episodic memory and future thinking during early childhood: Linking the past and future. *Developmental Psychobiology*, *57*(5), 552–565.

D'Argembeau, A., & Demblon, J. (2012). On the representational systems underlying prospection: Evidence from the event-cueing paradigm. *Cognition*, *125*(2), 160–167.

D'Argembeau, A., & Mathy, A. (2011). Tracking the construction of episodic future thoughts. *Journal of Experimental Psychology: General*, *140*(2), 258–271.

D'Argembeau, A., & Van Der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition*, *13*(4), 844–858.

D'Argembeau, A., & Van Der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*(2), 342–350.

D'Argembeau, A., & Van Der Linden, M. (2012). Predicting the phenomenology of episodic future thoughts. *Consciousness and Cognition*, *21*(3), 1198–1206.

D'Argembeau, A., Lardi, C., & Van Der Linden, M. (2012). Self-defining future projections: Exploring the identity function of thinking about the future. *Memory*, *20*(2), 110–120.

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van Der Linden, M. (2010). Component processes underlying future thinking. *Memory & Cognition*, *38*(6), 809–819.

Daniel, T. O., Said, M., Stanton, C. M., & Epstein, L. H. (2015). Episodic future thinking reduces delay discounting and energy intake in children. *Eating Behaviors*, *18*, 20–24.

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: Comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite*, *71*, 120–125.

Daselaar, S. M., Rice, H. J., Greenberg, D., Cabeza, R., LaBar, K. S., & Rubin, D. C. (2007). The spatiotemporal dynamics of autobiographical memory: neural correlates of recall, emotional intensity, and reliving. *Cerebral Cortex*, *18*(1), 217–229.

Dassen, F. C., Jansen, A., Nederkoorn, C., & Houben, K. (2016). Focus on the future: Episodic future thinking reduces discount rate and snacking. *Appetite*, *96*, 327–332.

De Vito, S., Buonocore, A., Bonnefon, J., & Della Sala, S. (2014). Eye movements disrupt spatial but not visual mental imagery. *Cognitive Processing*, *15*(4), 543–549.

De Vito, S., Buonocore, A., Bonnefon, J., & Della Sala, S. (2015). Eye movements disrupt episodic future thinking. *Memory*, *23*(6), 796–805.

Delaney, H. D., & Maxwell, S. E. (1981). On using analysis of covariance in repeated measures designs. *Multivariate Behavioral Research*, *16*(1), 105–123.

Demblon, J., & D'Argembeau, A. (2014). The organization of prospective thinking: Evidence of event clusters in freely generated future thoughts. *Consciousness and Cognition*, *24*, 75–83.

Dere, D., Zlomuzica, A., & Dere, E. (2019). Fellow travellers in cognitive evolution: Co-evolution of working memory and mental time travel? *Neuroscience and Biobehavioral Reviews*, *105*, 94–105.

Doherty, J., & Logie, R. H. (2016). Resource-sharing in multiple-component working memory. *Memory & Cognition*, *44*(8), 1157–1167.

Duff, S., & Logie, R. H. (1999). Storage and processing in visuo-spatial working memory. *Scandinavian Journal of Psychology*, *40*(4), 251–259.

Duff, S., & Logie, R. H. (2001). Processing and storage in working memory span. *The Quarterly Journal of Experimental Psychology*, *54*(1), 31–48.

El Haj, M., & Lenoble, Q. (2018). Eying the future: Eye movement in past and future thinking. *Cortex*, *105*, 97–103.

El Haj, M., & Lenoble, Q. (2018b). Eying the future: Eye movement in past and future thinking. *Cortex*, *105*, 97–103.

El Haj, M., & Moustafa, A. A. (2020). Pupil dilation as an indicator of future thinking. *Neurological Sciences*, *42*(2), 647–653.

Ersoy, P. K., & Tekcan, A. I. (2018). İstemli ve İstemsiz Otobiyografik Anılara Ulaşmada Doğrudan ve Üretici Geri Çağırmanın Rolü. *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi*, *58*(2), 1667.

Ferretti, F., Chiera, A., Nicchiarelli, S., Adornetti, I., Magni, R., Vicari, S., Valeri, G., & Marini, A. (2017). The development of episodic future thinking in middle childhood. *Cognitive Processing*, *19*(1), 87–94.

Fisk, A. D., Derrick, W. L., & Schneider, W. (1986). A methodological assessment and evaluation of dual-task paradigms. *Current Psychological Research & Reviews*, *5*(4), 315–327.

Fivush, R. (2008). Remembering and reminiscing: How individual lives are constructed in family narratives. *Memory Studies*, *1*(1), 49–58.

Fivush, R., Haden, C. A., & Reese, E. (2006). Elaborating on elaborations: Role of maternal reminiscing style in cognitive and socioemotional development. *Child Development*, *77*(6), 1568–1588.

Gaesser, B., Sacchetti, D., Addis, D. R., & Schacter, D. L. (2011). Characterizing age-related changes in remembering the past and imagining the future. *Psychology and Aging*, *26*(1), 80–84.

Gathercole, S. E., Pickering, S. J., Ambridge, B., & Wearing, H. (2004). The structure of working memory from 4 to 15 years of age. *Developmental Psychology*, *40*(2), 177–190.

Gatti, D., Somos, E., Mazzoni, G., & Jellema, T. (2022). Could direct and generative retrieval be two flips of the same coin? A dual-task paradigm study. *Cognitive Processing*, *23*(3), 513–519.

Guler, O., & Mackovichova, S. (2018). The role of executive function in autobiographical memory retrieval: does the type of cue word matter? *Memory*, *27*(4), 423–430.

Hallford, D. J., Takano, K., Raes, F., & Austin, D. W. (2020). Psychometric evaluation of an episodic future thinking variant of the Autobiographical Memory Test – Episodic Future Thinking-Test (EFT-T). *European Journal of Psychological Assessment*, *36*(4), 658–669.

Heyes, S. B., Zokaei, N., Van Der Staaij, I., Bays, P. M., & Husain, M. (2012). Development of visual working memory precision in childhood. *Developmental Science*, *15*(4), 528–539.

Hill, P. F., & Emery, L. (2013). Episodic future thought: Contributions from working memory. *Consciousness and Cognition*, *22*(3), 677–683.

Hu, B., Zhang, R., & Feng, T. (2023). Seeing the future: Connectome strength and network efficiency in visual network predict individual ability of episodic future thinking. *Neuropsychologia*, *179*, 108451.

Huitema, B. (2011). *The analysis of covariance and alternatives: Statistical methods for experiments, quasi-experiments, and single-case studies.* New York, NY: Wiley.

Irish, M., Addis, D. R., Hodges, J. R., & Piguet, O. (2012). Exploring the content and quality of episodic future simulations in semantic dementia. *Neuropsychologia*, *50*(14), 3488–3495.

Jaeggi, S. M., Buschkuehl, M., Perrig, W. J., & Meier, B. (2010). The concurrent validity of theN-back task as a working memory measure. *Memory*, *18*(4), 394–412.

Janssen, S. M. J., Kristo, G., Rouw, R., & Murre, J. M. J. (2015). The relation between verbal and visuospatial memory and autobiographical memory. *Consciousness and Cognition*, *31*, 12–23.

Kaplan, B. A., Reed, D. D., & Jarmolowicz, D. P. (2015). Effects of episodic future thinking on discounting: Personalized age-progressed pictures improve risky long-term health decisions. *Journal of Applied Behavior Analysis*, *49*(1), 148–169.

Kemps, E., & Tiggemann, M. (2007). Reducing the vividness and emotional impact of distressing autobiographical memories: The importance of modality-specific interference. *Memory*, *15*(4), 412–422.

Kirchner, W. K. (1958). Age differences in short-term retention of rapidly changing information. *Journal of Experimental Psychology*, *55*(4), 352–358.

Lehner, E., & D’Argembeau, A. (2016). The role of personal goals in autonoetic experience when imagining future events. *Consciousness and Cognition*, *42*, 267–276.

Logie, R. H., & Duff, S. (2007). Separating processing from storage in working memory operation span. In N. Osaka, R. H. Logie & M. D’Esposito (Eds.), *The Cognitive Neuroscience of Working Memory* (pp. 119-136). Oxford University Press.

Marchetti, G. (2014). Attention and working memory: two basic mechanisms for constructing temporal experiences. *Frontiers in Psychology*, *5*.

Maxfield, L., Melnyk, W. T., & Hayman, C. a. G. (2008). A working memory explanation for the effects of eye movements in EMDR. *Journal of Emdr Practice and Research*, *2*(4), 247–261.

McCabe, D. P., Roediger, H. L., McDaniel, M. A., Balota, D. A., & Hambrick, D. Z. (2010). The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology*, *24*(2), 222–243.

McDonough, I. M., & Gallo, D. A. (2009). Separating past and future autobiographical events in memory: Evidence for a reality monitoring asymmetry. *Memory & Cognition*, *38*(1), 3–12.

Meule, A. (2017). Reporting and Interpreting Working Memory Performance in n-back Tasks. *Frontiers in Psychology*, *8*.

Naito, M., & Suzuki, T. (2011). “When did I learn and when shall I act?”: The developmental relationship between episodic future thinking and memory. *Journal of Experimental Child Psychology*, *109*(4), 397–411.

Oberauer, K. (2002). Access to information in working memory: Exploring the focus of attention. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *28*(3), 411–421.

Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. T. (2005). N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Human Brain Mapping*, *25*(1), 46–59.

Ozbozdagli, S., Misirlisoy, M., Ozkan, T., & Atalay, N. B. (2018). Effects of primary task predictability and secondary task modality on lane maintenance. *Transportation Research. Part F, Traffic Psychology and Behaviour*, *57*, 97–107.

Perlman, S. B., Huppert, T. J., & Luna, B. (2015). Functional Near-Infrared spectroscopy evidence for development of prefrontal engagement in working memory in early through middle childhood. *Cerebral Cortex*, *26*(6), 2790–2799.

Piolino, P., Coste, C., Martinelli, P., Macé, A., Quinette, P., Guillery-Girard, B., & Belleville, S. (2010). Reduced specificity of autobiographical memory and aging: Do the executive and feature binding functions of working memory have a role? *Neuropsychologia*, *48*(2), 429–440.

Plancher, G., Gyselinck, V., & Piolino, P. (2018). The Integration of Realistic Episodic Memories Relies on Different Working Memory Processes: Evidence from Virtual Navigation. *Frontiers in Psychology*, *9*.

Postle, B. R., Idzikowski, C., Della Sala, S., Logie, R. H., & Baddeley, A. (2006). The selective disruption of spatial working memory by eye movements. *The Quarterly Journal of Experimental Psychology*, *59*(1), 100–120.

Puig, V. A., & Szpunar, K. K. (2017). The devil is in the details: Comparisons of episodic simulations of positive and negative future events. *Emotion*, *17*(5), 867–873.

Race, E., Keane, M. M., & Verfaellie, M. (2012). Losing sight of the future: Impaired semantic prospection following medial temporal lobe lesions. *Hippocampus*, *23*(4), 268–277.

Raghubar, K. P., Barnes, M. A., & Hecht, S. A. (2010). Working memory and mathematics: A review of developmental, individual difference, and cognitive approaches. *Learning and Individual Differences*, *20*(2), 110–122.

Redick, T. S., Broadway, J. M., Meier, M. E., Kuriakose, P., Unsworth, N., Kane, M. J., & Engle, R. W. (2012). Measuring working memory capacity with automated complex span tasks. *European Journal of Psychological Assessment*, *28*(3), 164–171.

Richmond, J. L., & Pan, R. (2013). Thinking about the future early in life: The role of relational memory. *Journal of Experimental Child Psychology*, *114*(4), 510–521.

Roberts, R. P., Schacter, D. L., & Addis, D. R. (2017). Scene construction and relational processing: separable constructs? *Cerebral Cortex*, *28*(5), 1729–1732.

Rodriguez-Jimenez, R., Avila, C., Garcia-Navarro, C., Bagney, A., De Aragon, A. M., Ventura-Campos, N., Martinez-Gras, I., Forn, C., Ponce, G., Rubio, G., Jimenez-Arriero, M. A., & Palomo, T. (2009). Differential dorsolateral prefrontal cortex activation during a verbal n-back task according to sensory modality. *Behavioural Brain Research*, *205*(1), 299–302.

Ros, L., Latorre, J. M., & Serrano, J. P. (2009). Working memory capacity and overgeneral autobiographical memory in young and older adults. *Aging, Neuropsychology, and Cognition*, *17*(1), 89–107.

Rubin, D. C. (2005). A Basic-Systems approach to autobiographical memory. *Current Directions in Psychological Science*, *14*(2), 79–83.

Rubin, D. C. (2006). The Basic-Systems model of episodic memory. *Perspectives on Psychological Science*, *1*(4), 277–311.

Rubin, D. C., Schrauf, R. W., & Greenberg, D. (2003). Belief and recollection of autobiographical memories. *Memory & Cognition*, *31*(6), 887–901.

Salgado, S., & Berntsen, D. (2019). My future is brighter than yours: the positivity bias in episodic future thinking and future self-images. *Psychological Research*, *84*(7), 1829–1845.

Schacter, D. L., & Addis, D. R. (2007). On the constructive episodic simulation of past and future events. *Behavioral and Brain Sciences*, *30*(3), 331–332.

Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: mechanisms and functions. *Current Opinion in Behavioral Sciences*, *17*, 41–50.

Schacter, D. L., Gaesser, B., & Addis, D. R. (2012). Remembering the past and imagining the future in the elderly. *Gerontology*, *59*(2), 143–151.

Schneider, B. A., Avivi-Reich, M., & Mozuraitis, M. (2015). A cautionary note on the use of the Analysis of Covariance (ANCOVA) in classification designs with and without within-subject factors. *Frontiers in Psychology*, *6*.

Segovia, M., Palma, M. A., & Nayga, R. M. (2020). Can episodic future thinking affect food choices? *Journal of Economic Behavior and Organization*, *177*, 371–389.

Sheldon, S., Amaral, R., & Levine, B. (2016). Individual differences in visual imagery determine how event information is remembered. *Memory*, *25*(3), 360–369.

Siddique, R. F., Shimul, A. M., Gias, A. U., Islam, M., & Khaled, S. M. (2015). The role of episodic buffer in episodic future thinking. *Universal Journal of Psychology*, *3*(1), 1–8.

Simmering, V. R. (2012). The development of visual working memory capacity during early childhood. *Journal of Experimental Child Psychology*, *111*(4), 695–707.

Snider, S. E., Deshpande, H. U., Lisinski, J., Koffarnus, M. N., LaConte, S. M., & Bickel, W. K. (2018). Working memory training Improves alcohol users' episodic future Thinking: A Rate-Dependent Analysis. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *3*(2), 160–167.

Stein, J. S., Tegge, A. N., Turner, J. K., & Bickel, W. K. (2017). Episodic future thinking reduces delay discounting and cigarette demand: an investigation of the good-subject effect. *Journal of Behavioral Medicine*, *41*(2), 269–276.

Strobach, T. (2019). The dual-task practice advantage: Empirical evidence and cognitive mechanisms. *Psychonomic Bulletin & Review*, *27*(1), 3–14.

Strobach, T. (2019). The dual-task practice advantage: Empirical evidence and cognitive mechanisms. *Psychonomic Bulletin & Review*, *27*(1), 3–14.

Strobach, T., & Schubert, T. (2017). Mechanisms of Practice-Related Reductions of Dual-Task Interference with Simple Tasks: Data and Theory. *Advances in Cognitive Psychology*, *13*(1), 28–41.

Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences*, *30*(3), 299–313.

Szpunar, K. K., & Radvansky, G. A. (2016). Cognitive approaches to the study of episodic future thinking. *Quarterly Journal of Experimental Psychology*, *69*(2), 209–216.

Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014). A taxonomy of prospection: Introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(52), 18414–18421.

Szpunar, K. K., Watson, J. M., & McDermott, K. B. (2007). Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(2), 642–647.

Tombu, M., & Jolicoeur, P. (2004). Virtually no evidence for virtually perfect Time-Sharing. *Journal of Experimental Psychology. Human Perception and Performance*, *30*(5), 795–810.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology*, *26*(1), 1–12.

Tulving, E. (2002). Episodic memory: from mind to brain. *Annual Review of Psychology*, *53*(1), 1–25.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*(5), 352–373.

Unsworth, N., Brewer, G. A., & Spillers, G. J. (2011). Variation in working memory capacity and episodic memory: Examining the importance of encoding specificity. *Psychonomic Bulletin & Review*, *18*(6), 1113–1118.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498–505.

Unsworth, N., Spillers, G. J., & Brewer, G. A. (2012). The role of working memory capacity in autobiographical retrieval: Individual differences in strategic search. *Memory*, *20*(2), 167–176.

Wiebels, K., Addis, D. R., Moreau, D., Van Mulukom, V., Onderdijk, K. E., & Roberts, R. P. (2020). Relational processing demands and the role of spatial context in the construction of episodic simulations. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *46*(8), 1424–1441.

Woolley, G. (2010). Developing reading comprehension: combining visual and verbal cognitive processes. *The Australian Journal of Language and Literacy, 33*(2), 108–125.

Zavagnin, M., De Béni, R., Borella, E., & Carretti, B. (2016). Episodic future thinking: the role of working memory and inhibition on age-related differences. *Aging Clinical and Experimental Research*, *28*(1), 109–119.

APPENDIX A: Instructions for the Experiment

GÖRSEL GRUP

2-geri yönergeleri.

Değerli katılımcı, bu aşamada sizden 2-geri görevi adı verilen bir görevi gerçekleştirmeniz beklenmektedir. Görev esnasında ekranda belli aralıklarla görünüp kaybolan mavi renkte kareler göreceksiniz. Bu kareler ekranda farklı konumlarda görünecekler. Yapmanız gereken şey, bu karelerin konumlarını dikkatle takip etmek.

Şimdi, sıradaki yönergeyi görmek için herhangi bir tuşa basabilirsiniz.

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Eğer size gösterilen kare şeklinin konumu 2 adım önce gösterilen kare şeklinin konumu ile aynı ise "H" tuşuna basmanız gerekmektedir.

Bir örnek görmek için herhangi bir tuşa basarak sıradaki aşamaya geçiniz.

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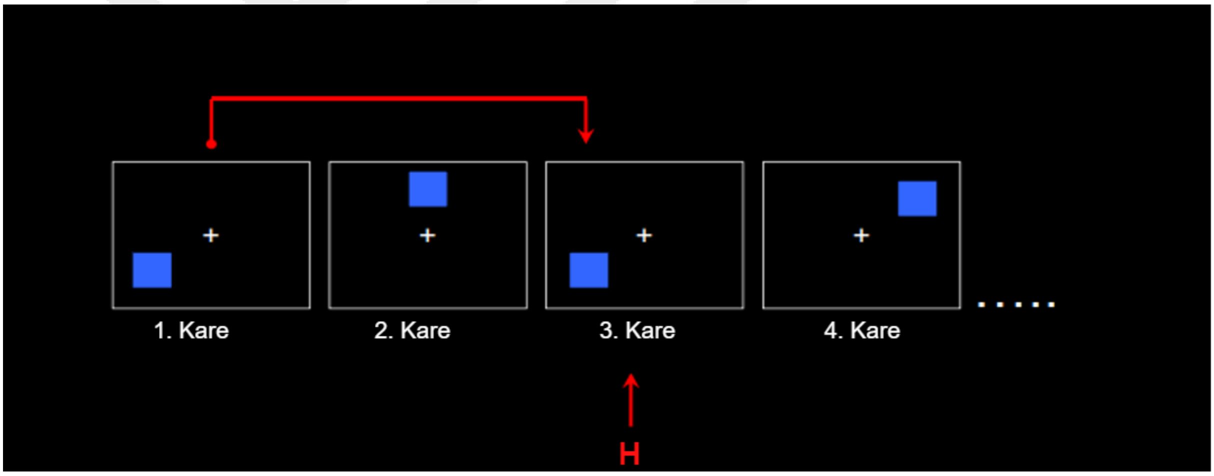

TEKLİ GÖREV

Epizodik Gelecek Düşüncesi Yönergeleri.

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Değerli katılımcı, şimdi sizden iki görevi aynı anda yapmanız beklenecektir. Az sonra yine karelerin konumlarını takip edeceksiniz. Bu karelerin konumlarını takip ederken ekranda bir sözcük gösterilecek. Bu sözcüğü görür görmez GELECEKTE gerçekleşme ihtimali olan belirgin bir olay oluşturmaya çalışın ve aklınıza bir olay gelir gelmez "BOŞLUK" tuşuna basın. Bu esnada karelerin konumlarını takip etme görevini de sürdürmeniz gerektiğini unutmayın!

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SÖZEL GRUP

2-geri yönergeleri.

Değerli katılımcı, bu aşamada sizden 2-geri görevi adı verilen bir görevi gerçekleştirmeniz beklenmektedir. Görev esnasında kulaklıktan belirli aralıklarla harfler duyacaksınız. Yapmanız gereken şey, bu harflerin sırasını dikkatle takip etmek.

Şimdi, sıradaki yönergeyi görmek için herhangi bir tuşa basabilirsiniz.

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Eğer size okunan harf 2 adım önce okunan harf ile aynı ise "H" tuşuna basmanız gerekmektedir.

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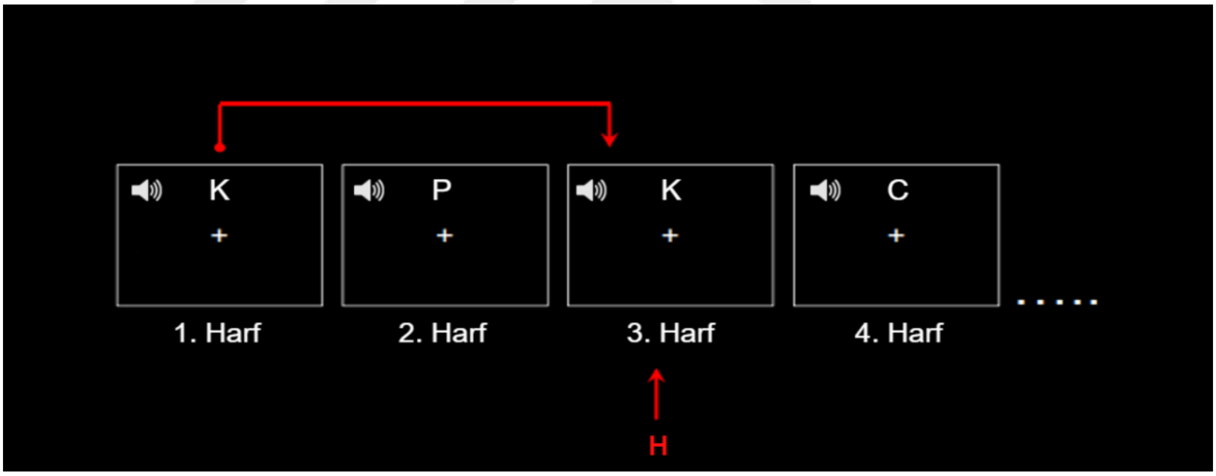

TEKLİ GÖREV

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APPENDIX B: Cue Words

İpucu Sözcükler	İmgelenebilirlik	Somutluk	Aşama
BİTKİ	6.50	6.81	Deney aşaması
BARDAK	6.74	6.72	Deney aşaması
GÖZLÜK	6.63	6.87	Deney aşaması
KEDİ	6.87	6.94	Deney aşaması
OTOBÜS	6.85	6.96	Pratik aşaması
PİZZA	6.58	6.88	Deney aşaması
ŞAPKA	6.56	6.93	Deney aşaması
FİNCAN	6.47	6.94	Pratik aşaması
AYAKKABI	6.44	6.88	Pratik aşaması
KAPI	6.60	6.64	Deney aşaması
KAĞIT	6.81	6.77	Pratik aşaması
BİLET	6.58	6.88	Deney aşaması

APPENDIX C: Phenomenology Questions

Epizodik Gelecek Düşüncesi Soruları

1- Bu olay, canlı bir olaydır. (1- Hiç / 7- Son derece canlı) (Vividness)
2- Bu olayı zihnimde canlandırdığımda, henüz gerçekleşmemiş olayı önceden yaşıyormuş gibi hissediyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Pre/re-experience)
3- Bu olayı zihnimde canlandırdığımda onu zihnimde görebiliyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Visual Imagery)
4- Bu olayı zihnimde canlandırdığımda onu zihnimde duyabiliyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Auditory Imagery)
5- Bu olayı zihnimde canlandırdığımda olayın geçtiği mekânda kimin/neyin nerede durduğunu biliyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Spatial Imagery)
6- Bu olayı zihnimde canlandırdığımda hissettiğim duygular (1- Son derece olumsuz / 7- Son derece olumlu) (Valence)
7- Bu olayı zihnimde canlandırdığımda yoğun duygular hissediyorum. (1- Hiç / 7- Son derece yoğun) (Intensity)
8- Bu olay hayatımda önemli bir yere sahip olacaktır. (1- Hiç / 7- Son derece önemli) (Personal Importance)
9- Bazı olayları zihnimizde canlandırdığımızda olayı doğrudan kendi gözümüzden görürken, bazı olayları kendimizi de dışarıdan görebilecek şekilde gözlemci perspektifinden görürüz. Bu olayı hangi perspektiften görüyorsunuz? (1- Kendi gözümden / 7- Gözlemci gibi) (Imagery Perspective)
10- Bu olayı daha önce istemli olarak zihnimde canlandırarak onun hakkında düşündüm ya da konuştum. (1- Hiç / 7- Çok sık) (Voluntary Rehearsal)
11- Bu olay, siz onu zihninizde canlandırmaya çalışmadığınız halde, aniden ve istemsizce zihninizde belirdi mi? (1- Hiç / 7- Çok sık) (Involuntary Rehearsal)
12- Bu olayı zihnimde canlandırmak (1- Çok zordu / 7- Çok kolaydı) (Ease of Imagining)
13- Bu olay, belli bir yer ve zamanda gerçekleşebilecek ve süresi bir tam günü (24 saati) aşmayacak bir olay olması sebebiyle belirgin (spesifik) bir olaydır. (1- Hiç / 7- Son derece belirgin) (Specificity)

Epizodik Bellek Soruları

1- Bu anı, canlı bir anıdır. (1- Hiç / 7- Son derece canlı) (Vividness)
2- Bu anıyı hatırladığımda, onu yeniden yaşıyormuş gibi hissediyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Pre/re-experience)
3- Bu anıyı hatırladığımda, onu zihnimde görebiliyorum. (1- Hiç / 7- Şu anda oluyormuş gibi) (Visual Imagery)
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8- Bu anı, hayatımda önemli bir yere sahiptir. (1- Hiç / 7- Son derece önemli) (Personal Importance)
9- Bazı anıları hatırladığımızda olayı doğrudan kendi gözümüzden görürken, bazı anıları kendimizi de dışarıdan görebilecek şekilde gözlemci perspektifinden görürüz. Bu anıyı hangi perspektiften görüyorsunuz? (1- Kendi gözümden / 7- Gözlemci gibi) (Imagery Perspective)
10- Gerçekleştiği zamandan bu yana, kendi isteğimle zihnimde bu anıya geri dönerek onun hakkında düşündüm ya da konuştum. (1- Hiç / 7- Çok sık) (Voluntary Rehearsal)
11- Bu anı, siz onu hatırlamaya çalışmadığınız halde, aniden ve istemsizce zihninizde belirdi mi? (1- Hiç / 7- Çok sık) (Involuntary Rehearsal)
12- Bu anıyı hatırlamak (1- Çok zordu / 7- Çok kolaydı) (Ease of Imagining)
13- Bu anı, belli bir yer ve zamanda gerçekleşmiş ve süresi bir tam günü (24 saati) aşmamış bir olayı içermesi sebebiyle belirgin (spesifik) bir anıdır. (1- Hiç / 7- Son derece belirgin) (Specificity)

APPENDIX D: Demographical and Strategy Evaluation Form

Yaş: ___
Cinsiyet: ___

Lütfen aşağıdaki soruları gelecek düşüncesi ve 2-geri görevini eş zamanlı bir şekilde yaptığınız koşulu göz önüne alarak cevaplayınız;

1-) Görevi yerine getirirken herhangi bir sınıflandırma, kümeleme vb. gibi stratejiler uyguladınız mı?
A-) Evet, gelecek düşüncesi ve 2-geri görevini eş zamanlı bir şekilde yaparken bir strateji uyguladım.
B-) Hayır, gelecek düşüncesi ve 2-geri görevini eş zamanlı bir şekilde yaparken bir strateji uygulamadım.
Cevabınız "Evet" ise ne tür bir strateji uyguladınız?

2- Olayı ipucu sözcüğü gördükten sonra mı aklınıza getirdiniz?
A-) Evet, olayı ipucu sözcüğü gördükten sonra aklıma getirdim.
B-) Hayır, olayı ipucu sözcüğü görmeden önce aklıma getirmiştim.

3- Anket sorularını yanıtlarken aklınıza gelen bu olayı zihninizde detaylandırmaya devam ettiniz mi?
A-) Evet, soruları yanıtlarken olayı zihnimde detaylandırmaya devam ettim.
B-) Hayır, soruları yanıtlarken olayı zihnimde detaylandırmaya devam etmedim.

4- Görevlerden birine diğerine kıyasla daha mı çok odaklandınız?
A-) Her ikisini de aynı anda yapmaya çalıştım.
B-) Sadece gelecek düşüncesi görevini yapmaya çalıştım.
C-) Sadece 2-geri görevini yapmaya çalıştım.

5- Olayı gözlerinizi kapatarak mı kurguladınız?
A-) Evet, olayı bilgisayar ekranına bakmadan, gözlerimi kapatarak kurgulamaya çalıştım.
B-) Hayır, olayı kurgulamaya çalışırken bilgisayar ekranına bakıyordum.

Lütfen aşağıdaki soruları geçmişi hatırlama ve 2-geri görevini eş zamanlı bir şekilde yaptığınız koşulu göz önüne alarak cevaplayınız;

6-) Görevi yerine getirirken herhangi bir sınıflandırma, kümeleme vb. gibi stratejiler uyguladınız mı?
A-) Evet, geçmişi hatırlama ve 2-geri görevini eş zamanlı bir şekilde yaparken bir strateji uyguladım.
B-) Hayır, geçmişi hatırlama ve 2-geri görevini eş zamanlı bir şekilde yaparken bir strateji uygulamadım.
Cevabınız "Evet" ise ne tür bir strateji uyguladınız?
7-) Anıyı ipucu sözcüğü gördükten sonra mı aklınıza getirdiniz?
A-) Evet, anıyı ipucu sözcüğü gördükten sonra aklıma getirdim.
B-) Hayır, anıyı ipucu sözcüğü görmeden önce aklıma getirmiştim.

8-) Anket sorularını yanıtlarken aklınıza gelen bu anıyı zihninizde detaylandırmaya devam ettiniz mi?
A-) Evet, soruları yanıtlarken anıyı zihnimde detaylandırmaya devam ettim.
B-) Hayır, soruları yanıtlarken anıyı zihnimde detaylandırmaya devam etmedim.

9-) Görevlerden birine diğerine kıyasla daha mı çok odaklandınız?
A-) Her ikisini de aynı anda yapmaya çalıştım.
B-) Sadece geçmişi hatırlama görevini yapmaya çalıştım.
C-) Sadece 2-geri görevini yapmaya çalıştım.

9-) Anıyı gözlerinizi kapatarak mı hatırladınız?
A-) Evet, anıyı bilgisayar ekranına bakmadan, gözlerimi kapatarak hatırlamaya çalıştım.
B-) Hayır, anıyı hatırlamaya çalışırken bilgisayar ekranına bakıyordum.

10-) Nörolojik ya da kronik bir hastalığınız var mı? Varsa belirtiniz.
11-) Düzenli Kullandığınız ilaçlarınız var mı? Varsa belirtiniz.
12-) Dün gece yaklaşık kaç saat uyudunuz?
A-) 6 saatten az
B-) 6-8 saat arası
C-) 8 saat veya daha fazla

13-) En son ne zaman yemek yediniz?
A-) 1 saatten az
B-) 1-4 saat arası
C-) 4 saat veya daha fazla

9- Görmenizi kolaylaştıran herhangi bir yardımcı araç (gözlük, lens vb.) kullanıyor musunuz? Eğer kullanıyorsanız deney esnasında gözlüğünüzü/lensinizi taktınız mı?
A-) Evet
B-) Hayır
Deneyle ilgili eklemek istedikleriniz (yorum vs.) varsa belirtebilirsiniz. ___
Aşağıdaki tabloda, her işlemde kullandığınız ele göre 'sol' veya 'sağ' hanesini işaretleyiniz. Örneğin yazı yazarken genellikle sağ fakat ara sıra sol elinizi kullanıyorsanız hem 'sağ' hanesine hem de sol hanesine bir adet **X** işareti koyunuz. Yazı yazarken daima sağ elinizi kullanıyorsanız sadece 'sağ' hanesine **X** koyunuz.

		Sol	**Sağ**
1	Yazmak		
2	Çizmek		
3	Taş atmak		
4	Makas kullanmak		
5	Diş fırçası kullanmak		
6	Bıçak kullanmak		
7	Kaşık kullanmak		
8	Süpürge kullanmak (üst el)		
9	Kibrit çakmak		
10	Kutunun kapağını açmak		

APPENDIX E: Complete-case Analyses

Participants

We calculated the sample size employing the widely used practice for analysis of covariance (see Cohen, 1988, p. 379; Huitema, 2011, p. 475). The sample size was calculated using MorePower 6.0.4 software, which is suitable for power analysis according to our experimental design (Campbell & Thompson, 2012). The analysis indicated that the sample size for the 2 (between subjects) x 2 (within-subjects) x 2 (within-subjects) mixed design analysis of covariance should include a minimum of 168 participants to achieve a power of .90, with an alpha error value of .05 and a medium effect size of Cohen's f = .25 (Cohen, 1988). However, considering the potential loss of participants that may occur due to various reasons, at least 15% more than the calculated maximum number of participants was aimed. Nine hundred three undergraduate students (171 female, 21 men, 1 not specified; mean age = 21.4 years, *SD* = 2.09, range 18 to 29) who were native speakers of Turkish and normal or corrected-to-normal vision from Istanbul Medipol University participated in the study in return for course credits. Nearly 68% of the participants reported sleeping for over 6 hours, and 71% had their last meal within 4 hours before joining the study. Right-handed, left-handed, and ambidextrous participants accounted for 90.7%, 7.3%, and 2.1% respectively. Four participants could not complete the operation span task and were excluded from the analysis. For reaction time analyses, we improved the reliability of our measurements by excluding trials in which participants failed to report an event after pressing the button (38 cases) and reported the event before pressing the button (8 cases). Additionally, we removed outliers (15 cases) to ensure normality in our data. For phenomenology analyses, we excluded responses from a total of 38 participants who did not report an event for any of the 14 scale questions in the questionnaire[9]. Since we intended to conduct three-way ANCOVA, only the participants who have successfully reported events in all experimental trials were included in the analysis (45%)[10]. Ultimately, these constraints left us with eighty-seven participants (78 female, 9 men; mean age = 21.4 years, *SD* = 1.95, range 18 to 28).

[9] We included trials where participants reported an event before pressing the button. The reason for this inclusion was the assumption that the participants had indeed come up with an event but remembered the button pressing only after reporting the event.

[10] We did not observe any missing patterns, but further discussion on this missing inflation will be discussed in the discussion section.

Results

In the following sections, we will first test our hypotheses. Firstly, we will describe the reaction time data (the interval between seeing the cue word and pressing the button) and probe the main effects and interactions. Subsequently, we will investigate phenomenology data, where participants rated their elaborations on the events after dual-tasking. Lastly, we will conduct correlational analyses for exploratory purposes.

Reaction Time

A three-way mixed ANCOVA was performed to investigate how visual and verbal secondary tasks affect the retrieval time of episodic future thinking and episodic memory events while controlling the effect of working memory capacity. We first centered the covariate as our experiment includes within-subject factor (Delaney & Maxwell, 1981; Schneider et al., 2015). The descriptive statistics are summarized in Table 1. We did neither observe any three-way interactions nor the effect of the covariate. Two-way interaction analysis showed that there was an interaction between groups and temporal directions $F(1, 77) = 4.15$, $p < .05$, $\eta_p^2 = .051$. Pairwise comparisons of estimated marginal means indicated no significant difference between groups[11]. We also did not observe a significant difference between temporal directions in the visual group. However, there was a significant difference between temporal directions in the verbal group, indicating that imagining a future event was slower than remembering a past event when performing a verbal working memory task concurrently ($p = .001$, %95 C.I. = [413.7, 1678.7]). Furthermore, we also observed a main effect of temporal direction $F(1, 77) = 8.47$, $p < .01$, $\eta_p^2 = .09$. This analysis suggests that remembering a past event ($M = 4979.9$, $SD = 233.7$) is faster than imagining a future event ($M = 5575.1$, $SD = 274.1$). Lastly, the main effect of task type was also significant $F(1, 77) = 20.83$, $p < .001$, $\eta_p^2 = .21$. The result indicates that the time spent on finding an event during the single-task condition ($M = 5997.8$, $SD = 306.5$) took more time compared to dual-task condition ($M = 4557.3$, $SD = 245.1$)..

[11] The comparisons were Bonferroni-corrected in here as well as in other analyses.

Table 1. Descriptive statistics for reaction times.

	Conditions	Groups	*M*	*SD*	*N*
Past Events	Single-task	Visual	5922.53	2986.1	43
		Verbal	5463.43	2745.2	37
		Total	5710.20	2868.4	80
	Dual-task	Visual	4457.51	2639.9	43
		Verbal	4055.49	1973.3	37
		Total	4271.57	2349.5	80
Future Events	Single-task	Visual	5710.14	3570.7	43
		Verbal	6886.76	3112.1	37
		Total	6254.32	3397.2	80
	Dual-task	Visual	5136.30	2926.5	43
		Verbal	4517.92	2673.4	37
		Total	4850.30	2811.8	80

Phenomenology

A three-way mixed ANCOVA was performed to investigate how visual and verbal secondary tasks affect the phenomenology of episodic future thinking and episodic memory events while controlling the effect of working memory capacity. The covariate was centered before running the analyses. The descriptive statistics are summarized in Table 3.

Table 3. Descriptive statistics of phenomenology ratings.

		Past Events				Future Events				
		Single		Dual		Single		Dual		
Items	Groups	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*N*
Vividness	Visual	5.73	1.64	5.70	1.37	5.59	1.53	5.50	1.66	44
	Verbal	5.83	1.29	5.50	1.42	5.89	1.38	5.83	1.34	36
	Total	5.78	1.49	5.61	1.39	5.73	1.46	5.65	1.52	80
Pre/Re-Experiencing	Visual	5.43	1.54	5.18	1.68	5.14	1.88	4.77	1.86	44
	Verbal	5.27	1.67	5.08	1.57	5.62	1.40	4.65	1.97	37
	Total	5.36	1.59	5.14	1.62	5.36	1.69	4.72	1.90	81
Visual Imagery	Visual	5.93	1.18	5.89	1.22	6.14	1.25	5.89	1.16	44
	Verbal	5.97	1.09	5.86	.91	6.24	.95	5.68	1.52	37
	Total	5.95	1.13	5.88	1.08	6.19	1.11	5.79	1.33	81
Auditory Imagery	Visual	5.27	1.88	4.76	1.97	5.16	1.90	4.89	2.09	45
	Verbal	5.35	1.60	4.92	1.73	5.35	1.62	5.11	1.77	37

	Total	5.30	1.75	4.83	1.86	5.24	1.77	4.99	1.94	82
Spatial Imagery	Visual	5.78	1.63	5.47	1.60	5.49	1.71	5.29	1.71	45
	Verbal	6.00	1.13	5.38	1.57	5.57	1.57	5.59	1.42	37
	Total	5.88	1.42	5.43	1.57	5.52	1.64	5.43	1.58	82
Intensity	Visual	4.93	1.77	4.53	1.75	4.27	1.87	4.56	1.81	45
	Verbal	4.51	1.93	4.49	1.90	5.03	1.97	4.95	1.54	37
	Total	4.74	1.85	4.51	1.81	4.61	1.94	4.73	1.70	82
Valence	Visual	4.64	2.27	5.04	1.82	5.09	1.84	4.87	1.90	45
	Verbal	4.35	2.09	4.41	2.22	5.30	1.94	4.89	2.05	37
	Total	4.51	2.19	4.76	2.02	5.18	1.88	4.88	1.95	82
Personal Importance	Visual	3.89	1.94	3.93	1.82	3.73	2.08	3.58	1.85	45
	Verbal	3.78	2.07	3.73	2.28	4.19	2.06	3.89	1.94	37
	Total	3.84	1.99	3.84	2.03	3.94	2.07	3.72	1.88	82
	Visual	3.87	1.91	3.20	2.02	3.22	2.03	3.27	1.97	45

Voluntary Rehearsal	Verbal	3.84	2.04	3.59	2.02	3.78	2.23	3.86	2.21	37
	Total	3.85	1.96	3.38	2.02	3.48	2.13	3.54	2.09	82
	Visual	4.40	1.98	4.69	1.99	4.33	2.00	4.67	1.85	45
Involuntary Rehearsal	Verbal	5.03	2.10	4.54	1.74	4.51	1.88	4.95	1.68	37
	Total	4.68	2.04	4.62	1.87	4.41	1.93	4.79	1.77	82
	Visual	5.73	1.49	5.36	1.72	5.76	1.31	5.42	1.68	45
Ease Of Imagining	Verbal	6.14	1.18	5.30	1.74	6.24	.95	5.51	1.60	37
	Total	5.91	1.37	5.33	1.72	5.98	1.18	5.46	1.64	82
	Visual	3.24	2.38	3.49	2.54	3.51	2.71	3.33	2.53	45
Imagery Perspective	Verbal	3.22	2.59	3.30	2.48	3.46	2.53	2.51	2.26	37
	Total	3.23	2.45	3.40	2.50	3.49	2.61	2.96	2.43	82
	Visual	6.00	1.75	5.67	1.91	5.67	1.82	6.07	1.29	43
Specificity	Verbal	6.11	1.72	6.27	1.07	6.08	1.46	5.84	1.55	37
	Total	6.05	1.73	5.95	1.59	5.86	1.66	5.96	1.41	80

Vividness.

The analysis results revealed no three-way interaction both between temporal direction, task type, and operation span $F(1, 77) = 0.05$, $p = .81$, $\eta_p^2 = .001$, as well as between temporal direction, task type, and group $F(1, 77) = 0.32$, $p = .57$, $\eta_p^2 = .004$. There was also no two-way interaction effect; the interaction between temporal direction and task type $F(1, 77) = 0.15$, $p = .69$, $\eta_p^2 = .002$, task type and group F(1, 77) = 0.05, $p = .81$, $\eta_p^2 = .001$, task type and operation span $F(1, 77) = 0.45$, $p = .50$, $\eta_p^2 = .006$, temporal direction and group $F(1, 77) = 1.97$, $p = .16$, $\eta_p^2 = .025$ and temporal direction and operation span $F(1, 77) = 0.52$, $p = .47$, $\eta_p^2 = .007$. Lastly, no main effects were observed for both temporal direction $F(1, 77) = 0.09$, $p = .92$, $\eta_p^2 = .000$, and task type $F(1, 77) = 0.58$, $p = .44$, $\eta_p^2 = .007$.

Pre/Re-experiencing.

The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 78) = 0.10$, $p = .75$, $\eta_p^2 = .001$. The three-way interaction between temporal direction, task type and operation span were significant $F(1, 78) = 7.08$, $p < .01$, $\eta_p^2 = .083$. Interestingly, the two-way interaction between temporal direction and task type was not significant $F(1, 78) = 1.51$, $p = .22$, $\eta_p^2 = .019$, suggesting that the interaction between temporal direction and task type is only observed with the effect of operation span. Pairwise comparisons showed that the participants rated more pre/re-experiencing of future events in the single-task condition than in the dual-task condition ($p < .01$, %95 C.I. = [.189, 1.133]), but this difference appears to depend on the levels of operation span (see Fig. 1). Furthermore, the two-way interactions between temporal direction and task type $F(1, 78) = 1.51$, $p = .22$, $\eta_p^2 = .019$, task type and group $F(1, 78) = 0.89$, $p = .34$, $\eta_p^2 = .011$, task type and operation span $F(1, 78) = 0.38$, $p = .53$, $\eta_p^2 = .005$., and temporal direction and group $F(1, 78) = 2.28$, $p = .13$, $\eta_p^2 = .028$ were not significant. There was a significant two-way interaction between temporal direction and operation span $F(1, 78) = 4.95$, $p < .05$, $\eta_p^2 = .060$., but temporal direction's main effect was not significant $F(1, 78) = 1.26$, $p = .26$, $\eta_p^2 = .016$. The scatterplots illustrate this interaction (see Fig. 2), showing that the centered operation span score is negatively associated with pre-experiencing of future events (averaged across task type), while that score is positively related to re-experiencing of past events (averaged across task type). Lastly, the main effect of task type was significant *F*(1,

78) = 7.09, $p < .01$, $\eta_p^2 = .083$. Pairwise comparisons showed that the participants rated more pre/re-experiencing in the single-task condition ($M = 5.36$, $SD = .15$) than in the dual-task condition ($M = 4.92$, $SD = .15$)

Fig. 1. The relationship between operation span and the pre-experiencing of imagining future events in both dual-task and single-task contexts.

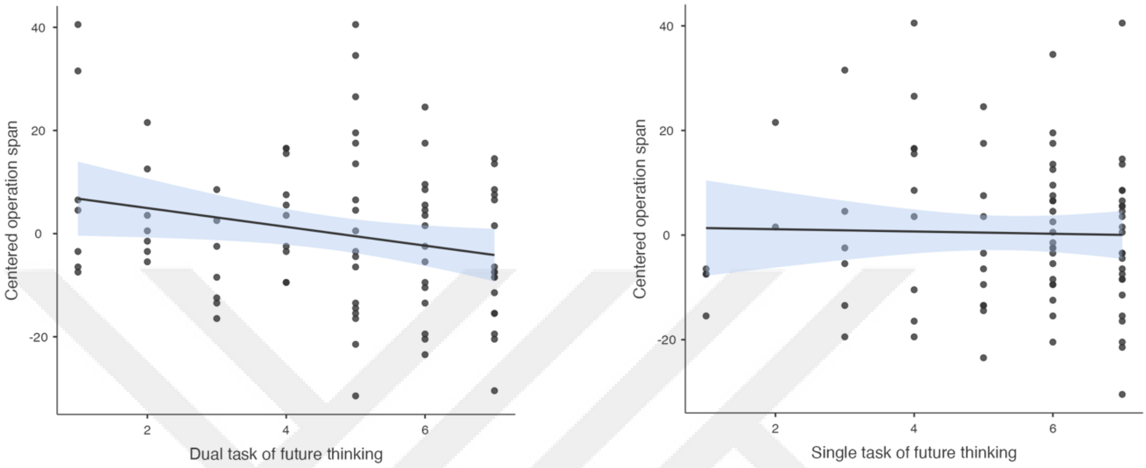
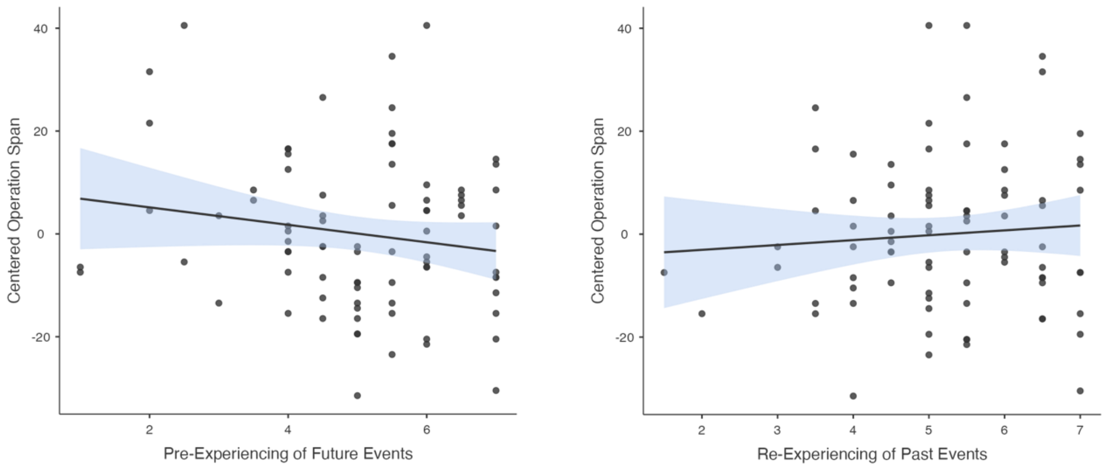


Fig. 2. The relationship between operation span and the pre-experiencing of imagining future events and remembering past events.



Visual Imagery

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 78) = 0.21$, $p = .64$, $\eta_p^2 = .003$, and temporal direction, task type and operation span $F(1, 78) = .01$, $p = .91$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 78) = 1.77$, $p = .18$, $\eta_p^2 = .022$, task type and group $F(1, 78) = 1.01$, $p = .31$, $\eta_p^2 = .013$, task type and operation span $F(1, 78) = 0.28$, $p = .59$, $\eta_p^2 = .004$, temporal direction and group $F(1, 78) = 0.15$, $p = .69$, $\eta_p^2 = .002$, and lastly temporal direction and operation span $F(1, 78) = 0.13$, $p = .71$, $\eta_p^2 = .002$. There was a main effect of task type $F(1, 78) = 5.40$, $p < .05$, $\eta_p^2 = .065$. Accordingly, the participants rated more visual imagery for the single-task condition ($M = 6.07$, $SD = .10$) than for the dual-task condition ($M = 5.82$, $SD = .11$). The main effect of temporal direction was not significant $F(1, 78) = 0.50$, $p = .47$, $\eta_p^2 = .006$.

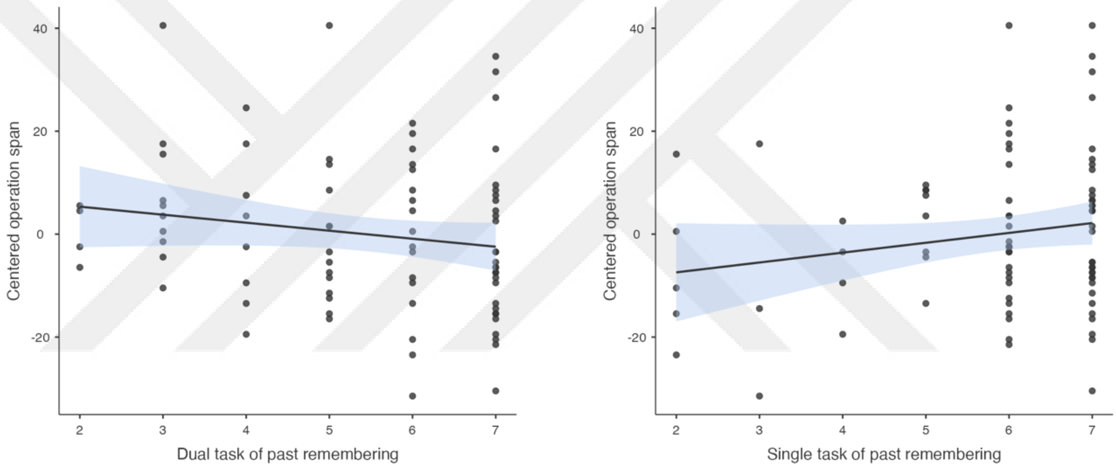
Auditory Imagery

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 79) = 0.01$, $p = .91$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 79) = 0.00$, $p = .93$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 79) = 0.48$, $p = .48$, $\eta_p^2 = .006$, task type and group $F(1, 79) = 0.00$, $p = .95$, $\eta_p^2 = .000$, task type and operation span $F(1, 79) = 0.13$, $p = .71$, $\eta_p^2 = .002$, temporal direction and group $F(1, 79) = 0.07$, $p = .78$, $\eta_p^2 = .001$, and temporal direction and operation span $F(1, 79) = .98$, $p = .75$, $\eta_p^2 = .000$. There was a main effect of task type $F(1, 79) = 5.20$, $p < .05$, $\eta_p^2 = .062$. Accordingly, the participants rated more auditory imagery for the single-task condition ($M = 5.28$, $SD = .16$) than for the dual-task condition ($M = 4.91$, $SD = .18$). The main effect of temporal direction was not significant $F(1, 79) = 0.09$, $p = .75$, $\eta_p^2 = .001$.

Spatial Imagery

The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 79) = 0.08$, $p = .77$, $\eta_p^2 = .001$. There was a three-way interaction between temporal direction, task type and operation span $F(1, 79) = 4.40$, $p < .05$, $\eta_p^2 = .053$. Pairwise comparisons showed that the participants rated more spatial imagery when they think of the past events in the single-task condition than in the dual-task condition ($p < .05$, %95 C.I. = [.019, .887]). However, this result indicates that the interaction between temporal direction and task type depends on the levels of operation span (see Fig. 3), as the two-way interaction between temporal direction and task type was not significant $F(1, 79) = 1.42$, $p = .23$, $\eta_p^2 = .018$. The remaining two-way interactions were also not significant; task type and group $F(1, 79) = 0.02$, $p = .87$, $\eta_p^2 = .000$, task type and operation span $F(1, 79) = 1.07$, $p = .30$, $\eta_p^2 = .013$, temporal direction and group $F(1, 79) = .43$, $p = .51$, $\eta_p^2 = .005$, temporal direction and operation span $F(1, 79) = 1.02$, $p = .31$, $\eta_p^2 = .013$. The main effects of task type $F(1, 79) = 2.61$, $p = .11$, $\eta_p^2 = .032$, and temporal direction $F(1, 79) = 1.15$, $p = .28$, $\eta_p^2 = .014$ were also not significant.

Fig. 3. The relationship between operation span and the spatial imagery of remembering past events in both dual-task and single-task contexts.



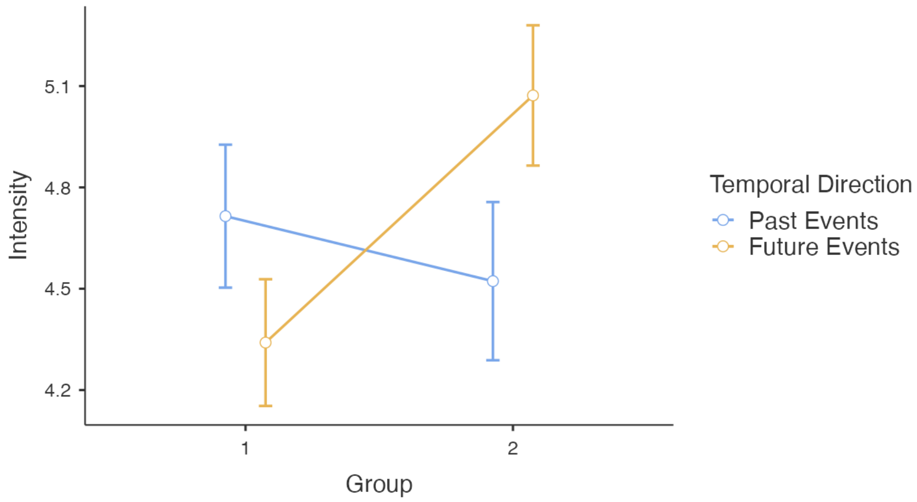
Valence

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 79) = .03$, $p = .85$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 79) = .00$, $p = .97$, $\eta_p^2 = .000$. Two-way interactions were also not significant; temporal direction and task type $F(1, 79) = 1.54$, $p = .21$, $\eta_p^2 = .019$, task type and group $F(1, 79) = .72$, $p = .39$, $\eta_p^2 = .009$, task type and operation span $F(1, 79) = 1.09$, $p = .29$, $\eta_p^2 = .014$, temporal direction and group $F(1, 79) = 2.82$, $p = .09$, $\eta_p^2 = .035$, and temporal direction and operation span $F(1, 79) = 2.10$, $p = .15$, $\eta_p^2 = .026$. There was a main effect of temporal direction $F(1, 79) = 3.98$, $p < .05$, $\eta_p^2 = .048$. Accordingly, the participants rated the future events ($M = 5.04$, $SD = .14$) more positively than the past events ($M = 4.60$, $SD = .17$). The main effect of task type was not significant $F(1, 79) = 0.82$ $p = .75$, $\eta_p^2 = .001$.

Intensity

The analysis showed no three-way interaction between temporal direction, task type and group $F(1, 79) = 0.92$, $p = .33$, $\eta_p^2 = .012$. The three-way interaction of temporal direction, task type and operation span task was also non-significant $F(1, 79) = 0.10$, $p = .75$, $\eta_p^2 = .001$. There was a significant two-way interaction between temporal direction and group $F(1, 78) = 7.79$, $p < .01$, $\eta_p^2 = .090$. Pairwise comparisons based on estimated marginal means revealed a significant group difference, suggesting that visual group rated less intensity than verbal group for future events ($p < .05$, %95 C.I. = [.165, 1.299]). Additionally, future events were rated as more intense than past events in verbal group ($p < .05$, %95 C.I. = [.070, 1.030]). The interaction effect is illustrated in Figure 4. There were no other two-way interactions; temporal direction and task type $F(1, 79) = 0.59$, $p = .44$, $\eta_p^2 = .007$, task type and group $F(1, 79) = 0.30$, $p = .86$, $\eta_p^2 = .000$, task type and operation span $F(1, 79) = 0.44$, $p = .50$, $\eta_p^2 = .006$, temporal direction and operation span $F(1, 79) = 1.70$, $p = .19$, $\eta_p^2 = .021$. The main effect of temporal direction $F(1, 79) = 0.30$, $p = .58$, $\eta_p^2 = .004$, and task type $F(1, 79) = 0.92$, $p = .76$, $\eta_p^2 = .001$ were also not significant.

Fig 4. Interaction between temporal direction and group (group 1 = visual, group 2 = verbal)



Personal Importance

The analysis results revealed no three-way interaction both between temporal direction, task type, and operation span $F(1, 79) = 0.35$, $p = .55$, $\eta_p^2 = .004$, as well as between temporal direction, task type, and group $F(1, 79) = 0.04$, $p = .83$, $\eta_p^2 = .001$. There was also no two-way interaction effect; the interaction between temporal direction and task type $F(1, 79) = 0.35$, $p = .55$, $\eta_p^2 = .004$, task type and group $F(1, 79) = 0.28$, $p = .59$, $\eta_p^2 = .004$, task type and operation span $F(1, 79) = 0.96$, $p = .33$, $\eta_p^2 = .012$, temporal direction and group $F(1, 79) = 1.18$, $p = .27$, $\eta_p^2 = .015$ and temporal direction and operation span $F(1, 79) = 0.30$, $p = .58$, $\eta_p^2 = .004$. Lastly, no main effects were observed for both temporal direction $F(1, 79) = 0.00$, $p = .95$, $\eta_p^2 = .000$ and task type $F(1, 79) = 0.32$, $p = .56$, $\eta_p^2 = .004$.

Imagery Perspective

No three-way interaction were observed both between temporal direction, task type, and operation span $F(1, 79) = 0.27$, $p = .60$, $\eta_p^2 = .003$, and between temporal direction, task type, and group $F(1, 79) = 0.50$, $p = .48$, $\eta_p^2 = .006$. Two-way interactions were also not significant; the interaction between temporal direction and task type $F(1, 79) = 2.04$, $p = .15$, $\eta_p^2 = .025$, task type and group $F(1, 79) = 1.04$, $p = .31$, $\eta_p^2 = .013$, task type and operation span $F(1, 79) = 0.24$, $p = .62$, $\eta_p^2 = .003$, temporal direction and group $F(1, 79) = 0.49$, $p = .48$, $\eta_p^2 = .006$, and temporal direction and operation span $F(1, 79) = 0.73$, $p = .78$, $\eta_p^2 = .001$. The main effects were also not significant for both temporal direction $F(1, 79) = 0.00$, $p = .95$, $\eta_p^2 = .000$ and task type $F(1, 79) = 0.19$, $p = .66$, $\eta_p^2 = .002$.

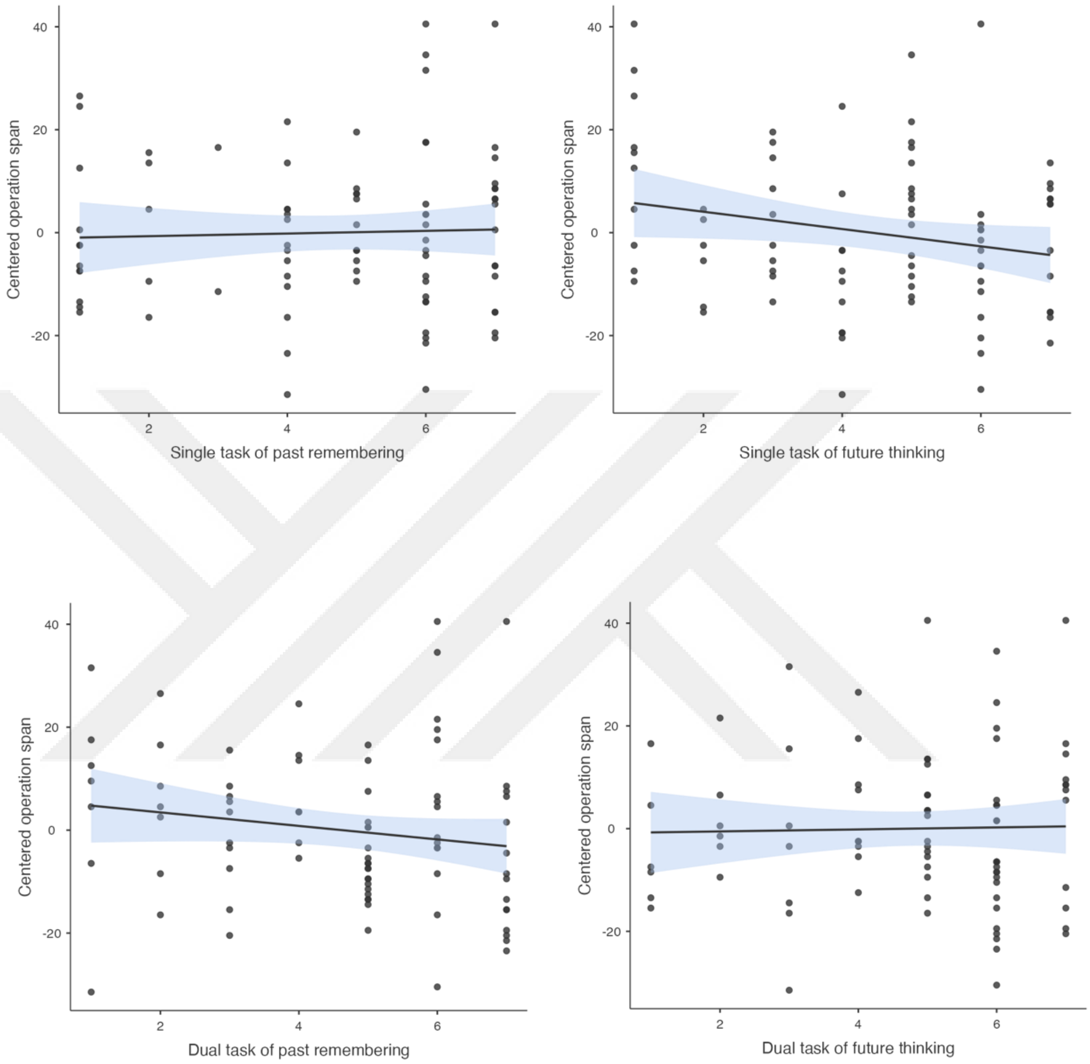
Voluntary Rehearsal

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 79) = 0.35$, $p = .55$, $\eta_p^2 = .005$, and temporal direction, task type and operation span $F(1, 79) = 0.27$, $p = .60$, $\eta_p^2 = .003$. Two-way interactions were also not significant; temporal direction and task type $F(1, 79) = 1.58$, $p = .21$, $\eta_p^2 = .020$, task type and group $F(1, 79) = 0.08$, $p = .77$, $\eta_p^2 = .001$, task type and operation span $F(1, 79) = 0.78$, $p = .37$, $\eta_p^2 = .010$, temporal direction and group $F(1, 79) = 0.40$, $p = .52$, $\eta_p^2 = .005$, and temporal direction and operation span $F(1, 79) = 0.95$, $p = .33$, $\eta_p^2 = .012$. The main effects were also not significant; task type $F(1, 79) = 0.89$, $p = .34$, $\eta_p^2 = .011$, temporal direction $F(1, 79) = 0.20$, $p = .65$, $\eta_p^2 = .003$.

Involuntary Rehearsal

The analysis showed no three-way interaction of temporal direction, task type and group $F(1, 79) = 0.36$, $p = .54$, $\eta_p^2 = .005$. The three-way interaction of temporal direction, task type and group was significant $F(1, 79) = 4.20$, $p < .05$, $\eta_p^2 = .051$. Temporal direction and task type's two-way interaction were not significant $F(1, 79) = 1.59$, $p = .21$, $\eta_p^2 = .020$, suggesting that this interaction depends on the levels of operation span. Although pairwise comparisons did not show any differences, this interaction may have caused by the correlations between operation span scores and within-subject factors. To delve into this interaction's nature, we analyzed how temporal direction and task type related to operation span measure (see Fig. 5). The scatterplot illustration elucidates this interaction by depicting a positive correlation between the single-task of past remembering and operation span, as well as between the dual-task of future thinking and operation span. Moreover, it indicates a negative correlation between the single-task of future thinking and operation span, as well as between the dual-task of past remembering and operation span. These reversed relationships likely underlie the nature of this interaction. The remaining two-way interactions were not significant; There was also no two-way interaction effect; the interaction between temporal direction and task type $F(1, 79) = 1.59$, $p = .21$, $\eta_p^2 = .020$, task type and group $F(1, 79) = 1.06$, $p = .30$, $\eta_p^2 = .013$, task type and operation span $F(1, 79) = 0.24$, $p = .62$, $\eta_p^2 = .003$, temporal direction and group $F(1, 79) = 0.00$, $p = .92$, $\eta_p^2 = .000$ and temporal direction and operation span $F(1, 79) = 0.20$, $p = .65$, $\eta_p^2 = .003$. The main effect of task type $F(1, 79) = 0.59$, $p = .44$, $\eta_p^2 = .008$, and direction $F(1, 79) = 0.85$, $p = .77$, $\eta_p^2 = .001$ were also not significant.

Fig. 5. Correlations between operation span and within-subject measures.



Ease of Imagining/Remembering

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 79) = 0.00$, $p = .97$, $\eta_p^2 = .000$, and temporal direction, task type and operation span $F(1, 79) = 0.28$, $p = .59$, $\eta_p^2 = .004$. Two-way interactions were also not significant; temporal direction and task type $F(1, 79) = 0.06$, $p = .79$, $\eta_p^2 = .001$, task type and group $F(1, 79) = 2.26$, $p = .13$, $\eta_p^2 = .028$, task type and operation span $F(1, 79) = 0.08$, $p = .77$, $\eta_p^2 = .001$, temporal direction and group $F(1, 79) = 0.31$, $p = .57$, $\eta_p^2 = .004$, and temporal direction and operation span $F(1, 79) = 0.58$, $p = .44$, $\eta_p^2 =$

.007. There was a main effect of task type $F(1, 79) = 15.54$, $p < .001$, $\eta_p^2 = .164$. Pairwise comparisons revealed that participants found imagining or remembering an event during the single-task ($M = 5.96$, $SD = .11$) easier than during the dual-task ($M = 5.39$, $SD = .14$). The main effect of temporal direction was not significant $F(1, 79) = 0.44$, $p = .50$, $\eta_p^2 = .006$.

Specificity

There were no three-way interaction effect for both temporal direction, task type and group $F(1, 79) = 3.06$ $p = .08$, $\eta_p^2 = .038$, and temporal direction, task type and operation span $F(1, 79) = 0.41$, $p = .84$, $\eta_p^2 = .001$. Two-way interactions were also not significant; temporal direction and task type $F(1, 79) = 0.28$, $p = .59$, $\eta_p^2 = .004$, task type and group $F(1, 79) = 0.22$, $p = .88$, $\eta_p^2 = .000$, task type and operation span $F(1, 79) = 0.28$, $p = .59$, $\eta_p^2 = .004$, temporal direction and group $F(1, 79) = 0.49$, $p = .48$, $\eta_p^2 = .006$, and temporal direction and operation span $F(1, 79) = 0.04$, $p = .83$, $\eta_p^2 = .001$. The main effects were also not significant; task type $F(1, 79) = 0.00$, $p = .99$, $\eta_p^2 = .011$, temporal direction $F(1, 79) = 0.32$, $p = .57$, $\eta_p^2 = .004$.

APPENDIX F: Informed Consent

Bilgilendirilmiş Onam Formu

Araştırmanın amacı nedir?

Bu araştırma, geçmişi hatırlama ve geleceği kurgulama becerilerinin çoklu görev becerileriyle nasıl bir bağlantısı olduğunu incelemektedir.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, sizden beklenen, bilgisayar karşısında kulaklık takarak birtakım bilişsel görevler yerine getirmenizdir. Çalışmaya katılım yaklaşık olarak 45-50 dakika sürmektedir.

Sizden topladığımız bilgileri nasıl kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Ankette, sizden kimlik veya kurum belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde istatistiksel analizler içinde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır. Sağladığınız veriler hiçbir şekilde kişisel bilgilerinizle eşleştirilmeyecektir.

Katılımınızla ilgili bilmeniz gerekenler:

Araştırma, genel olarak kişisel rahatsızlık verecek uyaran ve soru içermemektedir. Ancak, katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakabilirsiniz. Böyle bir durumda deney asistanına bilgi vermeniz yeterli olacaktır.

Bu bilgiler ışığında lütfen aşağıda uygun gördüğünüz seçeneği işaretleyin:

Araştırmaya katılmayı kabul ediyorum.

Araştırmaya katılmak istemiyorum.

APPENDIX G: Ethical Approval Statement

İSTANBUL MEDİPOL ÜNİVERSİTESİ
SOSYAL BİLİMLER BİLİMSEL ARAŞTIRMALAR ETİK KURULU
ETİK KURULU KARAR FORMU

<table>
<tr><td rowspan="6">BAŞVURU BİLGİLERİ</td><td>ARAŞTIRMANIN AÇIK ADI</td><td colspan="4">Görsel ve Sözel Çalışan Belleğin Epizodik Gelecek Düşüncesi Üzerindeki Rolü</td></tr>
<tr><td>KOORDİNATÖR/SORUMLU ARAŞTIRMACI UNVANI/ADI/SOYADI</td><td colspan="4">Burak YILDIRIM</td></tr>
<tr><td>KOORDİNATÖR/SORUMLU ARAŞTIRMACININ UZMANLIK ALANI</td><td colspan="4">Psikoloji Yüksek Lisans Öğrencisi</td></tr>
<tr><td>KOORDİNATÖR/SORUMLU ARAŞTIRMACININ BULUNDUĞU MERKEZ</td><td colspan="4">İstanbul</td></tr>
<tr><td>DESTEKLEYİCİ</td><td colspan="4">-</td></tr>
<tr><td>ARAŞTIRMAYA KATILAN MERKEZLER</td><td>TEK MERKEZ ⊠</td><td>ÇOK MERKEZLİ ☐</td><td>ULUSAL ⊠</td><td>ULUSLARARASI ☐</td></tr>
</table>

Sayfa 1

İSTANBUL MEDİPOL ÜNİVERSİTESİ
SOSYAL BİLİMLER BİLİMSEL ARAŞTIRMALAR ETİK KURULU
ETİK KURULU KARAR FORMU

	Belge Adı	Tarihi	Versiyon Numarası	Dili
Değerlendirilen Belgeler	ARAŞTIRMA PROTOKOLÜ/PLANI			Türkçe ☒ İngilizce ☐ Diğer ☐
	BİLGİLENDİRİLMİŞ GÖNÜLLÜ OLUR FORMU			Türkçe ☒ İngilizce ☐ Diğer ☐
Karar Bilgileri	**Karar No: 14**	**Tarih: 09/02/2023**		
	Yukarıda bilgileri verilen Sosyal Bilimler Bilimsel Araştırmalar Etik Kurulu başvuru dosyası ile ilgili belgeler araştırmanın gerekçe, amaç, yaklaşım ve yöntemleri dikkate alınarak incelenmiş ve araştırmanın etik ve bilimsel yönden uygun olduğuna **"oy birliği"** ile karar verilmiştir.			

İSTANBUL MEDİPOL ÜNİVERSİTESİ SOSYAL BİLİMLER BİLİMSEL ARAŞTIRMALAR ETİK KURULU	
BAŞKANIN UNVANI / ADI / SOYADI	Prof. Dr. Ali BÜYÜKASLAN

Unvanı/Adı/Soyadı	**Uzmanlık Alanı**	**Kurumu**	**Cinsiyet**		**Araştırma ile ilişki**		**Katılım ***		**İmza**
Prof. Dr. Ali BÜYÜKASLAN	İletişim Çalışmaları	İstanbul Medipol Üniversitesi	E ☒	K ☐	E ☐	H ☒	E ☒	H ☐	Uygundur
Dr.Öğr.Üyesi Sinan SEÇKİN	Hukuk	İstanbul Medipol Üniversitesi	E ☒	K ☐	E ☐	H ☒	E ☒	H ☐	Uygundur
Doç. Dr. Serhat YÜKSEL	Finans	İstanbul Medipol Üniversitesi	E ☒	K ☐	E ☐	H ☒	E ☒	H ☐	Uygundur
Doç. Dr. İhsan EKEN	Medya ve Reklam Araştırmaları	İstanbul Medipol Üniversitesi	E ☒	K ☐	E ☐	H ☒	E ☒	H ☐	Uygundur
Dr.Öğr.Üyesi Ela ARI	Psikoloji	İstanbul Medipol Üniversitesi	E ☐	K ☒	E ☐	H ☒	E ☒	H ☐	Görüş Bildirmedi

* :Toplantıda Bulunma

Sosyal Bilimler
Bilimsel Araştırmalar Etik Kurul Sekreteri
Burcu Sena TOSUN