PENSAMIENTO CREATIVO Y FUNCIONES EJECUTIVAS EN LA INFANCIA MEDIA

Desarrollo, relación y el rol mediador del aprendizaje cooperativo

UNIVERSIDAD DE ALMERÍA

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Junio, 2022

Universidad de Almería

Doctorado en Salud, Psicología y Psiquiatría

Pensamiento creativo y funciones ejecutivas en la infancia media: desarrollo, relación y el rol mediador del aprendizaje cooperativo.

Creative thinking and executive functions in middle childhood: development, relationship and the mediating role of cooperative learning.

Tesis doctoral

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Junio, 2022

Ser maestro fue una de las mejores decisiones que tomé nunca.

Nada recomendable si no aceptas que nada te pertenece;

nada envidiable si no crees

en el milagro de las personas y de la vida.

A la memoria de Agustín Burgos

Agradecimientos

A María teresa Daza González, mi directora de tesis, por haber puesto a mi dispos todos los medios posibles para llevar a cabo esta tesis doctoral. Por el apoyo en mome difíciles. Por abrirme las puestas de un mundo desconocido para mí y tener una paciencia infinita en mi proceso de aprendizaje profesional y personal. Me quedo con tu impecable y esmerado modo de trabajar.

A Verónica López Fernández, mi codirectora, por creer en las posibilidades de mi trabajo y animarme a emprender este camino. Por tratarme con mucha amabilidad, cariño y comprensión. Gracias por tu dedicación, tu apoyo y la paciencia durante todo este tiempo.

A Ana Merchán por ayudarme en la última etapa, y enseñarme, con mucha paciencia y optimismo, a ver los números de muchas maneras.

A mi madre, por escuchar siempre y por entenderme incluso en aquellos momentos en los que ni yo mismo me encuentro; y a mi padre.

A mis hermanas, Isa y Cristina, porque cuando vuelvo, a pesar de todo, del tiempo y la distancia, me hacéis sentir que sigo en casa.

A María por tu apoyo, cariño y amor, y a su familia.

A Maite S. por acompañarme en la distancia y en el tiempo, y enseñarme que todo es relativo excepto el corazón.

A Mari Ángeles por creer tanto en mí, incluso creer antes y más que yo mismo. Gracias por no dejar de ser mi amiga nunca.

A Ramón, por tu peculiar manera de estar siempre.

A María del Mar, por creer en mí y apoyarme en todo. Esto es parte de ''Calypso'', y lo sabes. Gracias por no abandonar en este eterno ''ya casi termino''.

A Antonio Burgos por todo el apoyo, por tus consejos, tu predisposición a compartir todo lo que sabes, y por la larga amistad que me estás regalando.

A José Luis y al Centro del Profesorado de Almería por ayudarme a visibilizar mis proyectos e inquietudes, y a ayudarme a crecer como profesional.

A mis amigos de mi tierra, Córdoba, y en especial a Clara, a Manu y a Jordi. A pesar del tiempo y la distancia, parte de lo que soy hoy os lo debo a vosotros.

A todos los niños y niñas que han participado en esta investigación, y en general, a todos los que me han dejado creer en ellos. Detrás de esto no hay números, hay mucho cariño y amor. Hay muchas familias y personitas que han creído en mí, creciendo y brindándome la confianza y la responsabilidad para llevarlos al lugar que he creído correcto. Gracias de todo corazón.

ÍNDICE DE CONTENIDOS

Índice de tablas

Índice de figuras

Tratamiento del género y el lenguaje inclusivo y no sexista
Atendiendo a los principios de economía del lenguaje y normas establecidas por la Real Academia Española, se usa el género gramatical masculino para hacer referencia a hombres y mujeres. El desdoblamiento de ambos géneros es usado en aquellas ocasiones que se ha considerado relevante y necesario mencionar.

1

Resumen/ Abstract

Resumen

El pensamiento creativo es un proceso complejo estrechamente relacionado con el aprendizaje y desarrollo del individuo. Es por ello, que tanto desde el ámbito de la investigación como el de la educación, se haya mostrado interés en este tópico, especialmente durante la infancia. El pensamiento creativo implica la habilidad para percibir, entender y generar ideas nuevas y relevantes, lo que sitúa a este constructo en una dimensión inherente a la capacidad adaptativa del pensamiento humano. Investigaciones recientes han establecido que existen ciertos procesos cognitivos estrechamente relacionados con el pensamiento creativo, entre los que se encuentran las funciones ejecutivas (FFEE). Las FFEE son aquellos procesos cognitivos y socio-emocionales de orden superior que permiten a las personas guiar sus pensamientos y acciones hacia una meta, así como controlar sus comportamientos y adaptarse a situaciones novedosas y complejas. Por lo tanto, el estudio del desarrollo de estos importantes constructos se hace prioritario, así cómo la relación que existe entre ellos. Esto nos ayudaría a mejorar nuestro conocimiento sobre su naturaleza, contribuyendo también a la mejora de los contextos de aprendizaje.

La presente tesis doctoral trata de abordar la relación y desarrollo del pensamiento creativo y las FFEE *cool* (Memoria de Trabajo -MT-, flexibilidad cognitiva, control inhibitorio y planificación) y *hot* (Inteligencia Emocional -IE- y Empatía) durante uno de los períodos más críticos para el desarrollo integral del individuo como es el último ciclo de Educación Primaria (de los 9 a los 12 años de edad). Además, puesto que la metodología de aula, concretamente el aprendizaje cooperativo, podría ser uno de los factores importantes para el desarrollo de dichos constructos, también se aborda su papel modulador en el desarrollo de estos. Por tanto, el objetivo general de la presente tesis doctoral consistió en estudiar tanto el desarrollo como las relaciones entre el pensamiento creativo y las FFEE a lo largo del tercer

ciclo de Educación Primaria, y las implicaciones del aprendizaje cooperativo como metodología de aula en dicho desarrollo. Para poder abordar dicho objetivo general se realizaron cuatro estudios.

En el *primer estudio*, llevado a cabo con alumnado de edades comprendidas entre 9 y 10 años, se observó que el pensamiento creativo (medido a través del Test CREA) podía ser potenciado a través de un programa estructurado de actividades de lecto-escritura implementado en el aula a través de la metodología de aprendizaje cooperativo. Además, se observó una correlación positiva entre el desempeño en la tarea de pensamiento creativo y el rendimiento académico, medido a través del promedio de calificaciones escolares. En el *segundo estudio* investigamos los cambios que se producen en los componentes ejecutivos *cool* (memoria de trabajo -MT-, control inhibitorio, flexibilidad cognitiva y planificación) y *hot* (inteligencia emocional -IE- y empatía), durante el último ciclo de la Educación Primaria (entre los 9 y los 12 años). Los resultados mostraron una mejoría en los componentes de MT, flexibilidad cognitiva y planificación. Además, se observó que la metodología basada en el aprendizaje cooperativo, en comparación con el aprendizaje individual, podría potenciar las mejoras en MT y en el componente de auto-control de la IE. En el *tercer estudio* se observó que entre los 9 y los 12 años hay una mejoría significativa en el pensamiento creativo (medido a través del Test CREA). Además, también se pudo observar que esta mejoría parece estar potenciada en aquellos alumnos con los que se utiliza como metodología de aula el aprendizaje cooperativo, en comparación con aquellos con los que se emplea el aprendizaje individual. Por último, en el *cuarto estudio*, se examinó la relación entre el desempeño en una prueba de pensamiento creativo (PIC-N) y el rendimiento en tareas de FFEE *cool* (MT, flexibilidad cognitiva, control inhibitorio y planificación) en niños y niñas del último curso de la Educación Primaria. Mediante el análisis clúster, se formaron dos grupos de niños en función de su rendimiento en la prueba de pensamiento creativo (grupo alto y grupo bajo). Los resultados mostraron que los niños del grupo alto en pensamiento creativo tenían un rendimiento significativamente mejor que el grupo bajo en las tareas ejecutivas de MT y flexibilidad cognitiva. Además, también se observó que el grupo alto en pensamiento creativo estaba mayoritariamente formado por los niños con los que durante el último ciclo de la Educación Primaria se había utilizado el aprendizaje cooperativo como metodología de aula.

Así pues, estos hallazgos subrayan la importancia de estudiar el pensamiento creativo y las FFEE (*cool y hot*) durante un período de transición entre la infancia y la adolescencia, en el cual tienen lugar importantes cambios, tanto cognitivos como socio-emocionales, que podrían ser trascendentes durante todo el ciclo vital. Dada la estrecha relación que guardan dichos componentes con los procesos de aprendizaje, estos resultados ponen de manifiesto la importancia de analizar los factores contextuales que podrían influir en su desarrollo, especialmente las metodologías de aula. Las características diferenciadoras de ciertas prácticas metodológicas dentro del contexto escolar podrían influir en las interacciones dentro del aula y favorecer la predisposición hacia el aprendizaje, y por ende, beneficiar el desarrollo cognitivo y socio-emocional de los niños y niñas. Por lo tanto, se resalta la importancia de investigaciones dentro del contexto escolar que ayuden a entender cómo el pensamiento creativo y las FFEE se relacionan y desarrollan, y la mediación de aquellos factores contextuales que coexisten dentro del aula, con la finalidad de mejorar los procesos de aprendizaje.

Abstract

Creative thinking is a complex process closely related to the individual's learning and development. Both research and education fields have shown interest in this topic, especially during childhood. Creative thinking implies the ability to perceive, understand and generate new and relevant ideas, which places this construct in a dimension inherent to the adaptive capacity of human though. Recent research has established that there are certain cognitive processes closely related to creative thinking, including executive functions (FFEE). FFEE are those higher-order cognitive and socio-emotional processes which allow people to guide their thoughts and actions towards a goal, as well as control behaviours and adapt to new and complex situations. Therefore, the study of the development of these important constructs is a priority, as well as the relationship that exists between them, and this would hence help us understand the nature of the executive functions and consequently the improvement of learning contexts.

This doctoral thesis tries to address the relationship and development of creative thinking and the EEFF *cool* (Working Memory -WM-, cognitive flexibility, inhibitory control and planning) and *hot* (Emotional Intelligence -EI- and Empathy) during a critical period for the integral development of individuals, such as the last cycle of Primary Education (9-12 years). In addition, we have considered the classroom methodology, specifically cooperative learning, as the backbone of teaching practice, thanks to which individual characteristics and the environment are articulated and interact. Given the transcendental role of this factor, the possible involvement in the development of creative thinking and EEFF has been taken into account. Consequently, the general objective of this doctoral thesis was to study both the development and the relationships between creative thinking and executive functions

throughout the third cycle of Primary Education (9 and 12 years), and the implications of cooperative learning as a classroom methodology in said development. In order to address this general objective, four studies were carried out.

In the *first study*, which was carried out with students between the ages of 9 and 10, it was observed that creative thinking (measured through the CREA Test) could be enhanced through a structured program of reading-writing activities implemented in the classroom through the cooperative learning methodology. In addition, a positive correlation was observed between performance on the creative thinking task and academic performance, measured through the average of school grades (*GPA*). In the *second study*, we investigated the changes that occur in the *cool* (working memory -MT-, inhibitory control, cognitive flexibility and planning) and *hot* (emotional intelligence -EI- and empathy) executive components across the last cycle of Primary Education (between 9 and 12 years). The results showed an improvement in the components of WM, cognitive flexibility and planning. In addition, it was observed that the methodology based on cooperative learning, compared to individual learning, could enhance improvements in WM and in the self-control component of EI. In the *third study*, significant improvement was observed in creative thinking between the ages of 9 and 12 (measured through the CREA Test). In addition, it was also possible to note that this improvement seems to be enhanced in those students involved in cooperative learning as a classroom methodology, compared to the students involved in individual learning. Finally, in the *fourth study*, the relationship between a creative thinking test performance (PIC-N) and *cool* FFEE tasks performance (WM, cognitive flexibility, inhibitory control and planning) in boys and girls at the last year of Primary education was examined. Using cluster analysis, two groups of children were formed based on the creative thinking test performance (high group and low group). Results showed that the high creative thinking group performed significantly better than the low group on WM tasks and cognitive flexibility. In addition, it was also observed that the high creative thinking group was mainly composed of children who participated in cooperative learning as a classroom methodology during the last cycle of Primary Education.

Consequently, our findings underline the importance of studying creative thinking and FFEE (*cool* and *hot*) during a transition period between childhood and adolescence in which important changes take place, both cognitive and socio-emotional, which could be transcendent throughout the life span. Given the close relationship between these components and learning processes, our findings highlight the importance of analysing the contextual factors that could influence their development, especially classroom methodologies. The differential characteristics of certain methodological practices within the school context could influence the interactions in the classroom and favour the predisposition towards learning, and hence benefit the cognitive and socio-emotional development of children. Therefore, the importance of research within schools to help understand how creative thinking and FFEE are related and develop, and the mediation of those contextual factors that coexist within the classroom in order to improve the learning processes must be highlighted.

2

Introducción

El estudio del pensamiento creativo ha llevado a la comunidad científica a centrar sus esfuerzos en la observación de su desarrollo y de los procesos cognitivos que subyacen de la ideación creativa. Dado que, ni el pensamiento creativo ni los procesos cognitivos y/o socio-emocionales se desarrollan de manera aislada, dichos estudios, generalmente, han tenido en cuenta factores contextuales, entre los que podemos destacar los contextos de aprendizaje, especialmente las metodologías de aula.

La presente tesis doctoral se centra fundamentalmente en tres tópicos: el pensamiento creativo, los aspectos cognitivos (*cool*) y socio-emocionales (*hot*) de las FFEE, y el aprendizaje cooperativo como factor contextual. Dada la complejidad en relación a la conceptualización de cada uno de ellos, en el marco teórico de la presente tesis se tratará de ofrecer una línea lógica que ayude a entender la naturaleza y las relaciones entre pensamiento creativo, FFEE y aprendizaje cooperativo, y que además ayude a interpretar los hallazgos y conclusiones de los cuatro estudios empíricos que conforman este trabajo.

Así pues, en un primer lugar, partiremos de una conceptualización global de creatividad, así como de sus dimensiones. Seguidamente, trataremos de explicar qué entendemos por pensamiento creativo, así como su desarrollo e implicación en los procesos de aprendizaje. De la misma manera, abordaremos la conceptualización de las FFEE, las características, su desarrollo a través de la etapa infantil (especialmente al final de dicha etapa) y su implicación en el contexto escolar. Asimismo, se abordarán las relaciones de estos dos constructos (pensamiento creativo y FFEE) basándonos en estudios empíricos que sustentan, además, los resultados descritos a lo largo de este trabajo.

Finalmente, abordamos la conceptualización del aprendizaje cooperativo como metodología de aula, elemento transversal de los cuatro estudios empíricos, el cual es tratado como un factor contextual que podría estar implicado en el desarrollo del pensamiento creativo y las FFEE. Por lo tanto, tras una descripción exhaustiva de las característica y cualidades del aprendizaje cooperativo, realizaremos una aproximación al papel que tiene dicha metodología de aula en el desarrollo y rendimiento de los procesos de pensamiento creativo y las FFEE (*cool* y *hot*).

2.1 Creatividad

La creatividad es un tema controvertido que ha ocupado innumerables estudios a lo largo de los últimos sesenta años. A pesar de ello, existen importantes dificultades para definir de manera universal dicho término, ya que este puede ser abordado desde distintas perspectivas y ámbitos, así como la innovación técnica, el aprendizaje y la enseñanza, el mundo empresarial, las artes y las ciencias, y muchos otros campos. Sea cómo sea, ya en 1950, Guilford vaticinaba que la creatividad era un constructo complejo e inherente al ser humano, que además contribuiría al desarrollo social. Presumiblemente, en la creatividad podría radicar la capacidad adaptativa del ser humano; el potencial para innovar en condiciones cambiantes, y aspectos fundamentales para nuestra propia existencia (Fumoto et al., 2012). Es por ello que Guilford (1950), en su discurso presidencial a la Asociación Americana de Psicología (APA), reivindicara la necesidad de investigaciones en este campo. Runco y Sakamoto (1999, p.62) afirman que la creatividad "*se encuentra entre las más complejas conductas humanas. Parece estar influida por una amplia serie de experiencias evolutivas, sociales y educativas, y se manifiesta de maneras diferentes en una diversidad de campos*". A pesar de los numerosos intentos de conceptualización a lo largo de los últimos años, el escenario sigue siendo confuso.

Creatividad es un término que se refiere a la generación de ideas nuevas, apropiadas y útiles. Es decir, para considerar que una idea sea creativa no es suficiente solo con la novedad y originalidad de la misma, sino que esta debe ser entendida, además, en un determinado contexto (cultural, histórico y/o social). Esta visión de tradición sociocultural se centra en la observación de la creatividad a través del valor y repercusión del producto creativo. Dicho enfoque o interpretación de la creatividad pone de valor los logros individuales de personas altamente creativas como pueden ser artistas, científicos y personas célebres que han generado productos innovadores de gran importancia para el desarrollo social y cultural. Dicha interpretación de la creatividad, si bien es válida, deja en la penumbra otros aspectos importantes sobre este complejo constructo.

Otro enfoque en esta voluntad por definir los parámetros conceptuales que acoten el término de creatividad se centra en el proceso creativo por el cual se generan esas ideas novedosas y apropiadas, útiles y suficientemente valoradas. Desde esta perspectiva individualista, se pone el foco en los procesos (principalmente cognitivos) implicados en el comportamiento creativo. Esta distinción rompe con la idea tradicional de que la creatividad es algo reservado para unas determinadas personas, pero aún así no es completa ya que no contempla su carácter multidimensional. Por esta razón, el investigador y educador Mel Rhodes (1961) propuso un modelo a través del cual la creatividad pudiera conceptualizarse teniendo en cuenta las distintas dimensiones de esta. De acuerdo con este modelo (Modelo de las 4 '"P"), la creatividad debe analizarse desde cuatro dimensiones específicas: *la persona, el producto, el proceso, y la prensa* (contexto). De esta manera, la creatividad es abordada y analizada desde diferentes perspectivas: a) como un rasgo específico o característica de la *persona* creativa; b) como *producto* original, novedoso y útil; c) como *proceso* de pensamiento creativo o cognición creativa, que implica aquellos procesos cognitivos y estrategias meta-cognitivas que originan las producciones creativas ; y d) como *prensa* o *contexto*, el cual puede potenciar o inhibir el potencial creativo (ej. entorno familiar, contexto escolar), y, en términos sociales y culturales, determina la viabilidad y/o trascendencia del producto creativo. Por lo tanto, este modelo integra cuatro dimensiones complementarias; es un modelo integral que asume que la creatividad está presente en todas las personas, y es definida en función a unos rasgos de personalidad específicos. Dichos rasgos son complementarios a los procesos (cognitivos y estrategias meta-cognitivas) de la producción creativa, es decir, a la generación de productos novedosos y valorados dentro del contexto en el que se desenvuelve el sujeto (Zeng et al., 2011).

Persona

Cuando hablamos de creatividad desde la dimensión de la *persona* nos referimos a las características individuales, es decir, a la disposición individual hacia la búsqueda de respuestas en la resolución de un determinado problema, observada esta a través de un determinado comportamiento o conducta (curiosidad, perseverancia), y que viene dado por los propios rasgos de personalidad y la motivación intrínseca. Así pues, en el estudio de la creatividad se incluyen dichos rasgos de personalidad, incluyendo los propios intereses y motivaciones, y los conocimientos del individuo y/o el dominio en una determinada materia (Perkins, 1993). Por tanto, el producto creativo viene dado, entre otras cosas, y cómo veremos más adelante, por las acciones o estrategias emprendidas en determinadas circunstancias y en base a unas características individuales. En otras palabras, las respuestas (productos o ideas) son el resultado de una larga ecuación de elementos, entre los que se encuentran los conocimientos, las experiencias, las circunstancias y las motivaciones intrínsecas del sujeto.

Proceso

Durante la generación de ideas para resolución de un determinado problema o situación se dan una serie de procesos mediante los cuales los individuos adquieren y manipulan información para generar nuevas ideas. Numerosos investigadores han tratado de definir cuales son dichos procesos, y ofrecer una secuencia lógica que ayude a entender la toma de decisiones y respuestas en la resolución de un problema determinado. Por ejemplo, Basadur et al. (1982) describió un proceso de cinco etapas: a) *definición del problema*. Esta implica la reformulación del problema antes de comenzar a formular respuestas.; b) *recuperación de la información* relacionada con el problema, la cual es paralela a la codificación de dicha información (Mumford et al., 1996); c) *generación potencial de respuesta,* que implica la categorización y reorganización de la información; d) g*eneración de criterios para evaluación* y adecuar las posibles soluciones a los requerimientos del problema o tarea; y e) s*elección de una solución e implementarla*.

Wallas (1926) propuso otro modelo, resultado de la sistematización de modelos anteriores: Dewey (1910) y Poincaré (1913). El modelo de Wallas (1926) propone cuatro fases: a) *Preparación*: encuentro, identificación y análisis de un problema determinado; b) *Incubación*: acto involuntario, no consciente y pasivo, en el que el individuo se encuentra en un estado de ''tensión'' psíquica de espera previo a la generación de la respuesta: c) *Iluminación*: la presentación súbita y (aparentemente) espontánea de ideas; y d) *Verificación*: momento de evaluación de la idea y adaptación al contexto.

Sea cual sea el modelo que apliquemos para la caracterización de los procesos creativos, existen dos pilares básicos: la información en sí misma y cómo dicha información es procesada. Dicha información se refiere tanto a la propia del individuo (e.j. el conocimiento en un determinado dominio) como a la codificación de la nueva información. A su vez, esta información es gestionada por procesos (cognitivos y meta-cognitivos) para la generación de ideas adecuadas y/o alternativas en la resolución de un determinado problema.

Producto

El producto creativo es el resultado de los componentes descritos anteriormente: la persona y los procesos. Este puede ser analizado desde distintas perspectivas: a) desde la naturaleza del mismo (material o inmaterial); b) desde el campo o ámbito de aplicación (artístico, científico); y c) desde la repercusión del mismo, es decir, la trascendencia que pueda tener, lo cual puede ir desde lo individual (repercusión personal) a lo colectivo (repercusión social) (Simonton, 2004). En este sentido, Kaufman y Beghetto (2009) proponen una clasificación los productos creativos en función a su repercusión, incluyendo aquella creatividad cotidiana que implica productos creativos distintos de los logros de personas célebres dentro del mundo de las artes, las ciencias o el deporte. La creatividad cotidiana, si bien no posee de una repercusión social significativa (como en otros niveles de profesionales dentro de un ámbito), sí puede ser de gran utilidad individual en la resolución de problemas cotidianos o la gestión de las relaciones interpersonales, entre otros. Además, esta clasificación considera aquella creatividad que implica las percepciones e interpretaciones implícitas en el aprendizaje. Un estudiante de 5º grado de Educación Primaria puede generar ideas creativas significativamente importantes para su aprendizaje cuando maneja un concepto nuevo o inventa una metáfora, o relaciona dos conceptos aparentemente inconexos para resolver un determinado problema. Este tipo de productos implícitos en los procesos de aprendizaje son definidos como ''interpretaciones novedosas y personalmente útiles de experiencias, acciones y eventos'' (Beghetto y Kaufman, 2007; p. 73). Esta concepción de creatividad nos permite interpretar los procesos de construcción personal del conocimiento y entendimiento en un determinado contexto.

Contexto

El contexto (o press), hace referencia a las relaciones que se establecen dentro del entorno en el que la persona está inmersa; es decir, el espacio en el que coexisten el individuo y los diferentes agentes que pueden intervenir (o interferir) en la creatividad de dicho individuo. Dentro de este espacio, es considerado el contexto socio-cultural una de elementos principales, en el que se incluyen la educación y las relaciones sociales, lo cual determina el bagaje en cuanto a experiencias y conocimientos del sujeto. Es por ello, que dicho contexto sea tan determinante en los procesos de aprendizaje como esencial en el apoyo de la creatividad.

De manera más específica, investigaciones desde distintos ámbitos (entorno laboral, educacional, familiar, etc) han tratado de identificar aquellas características del contexto que puedan potenciar o inhibir la producción creativa (Amabile y Gryskiewics, 1989). También los entornos educativos han sido estudiados, identificándose como determinantes la *participación de los/las estudiantes* (aprendizaje activo, la investigación y exploración a través de actividades abiertas, la cooperación, expresión de ideas a través de distintos canales), el *entorno físico* (los espacios de aprendizaje abierto y facilitadores de múltiples experiencias, que permitan trabajar en distintas estructuras grupales, recursos materiales diversos), y *clima de aprendizaje* (relación estudiante-docente, estudiante-estudiante, abierto a la comunicación libre y de confianza) (Richardson y Mishra, 2018). También las familias, así como las características socio-demográficas (culturales, económicas, educacionales) son determinantes en el desempeño creativo del individuo (Runko, 2014).

Si bien los cuatro componentes del modelo de Rhodes (1961) desempeñan un papel importante en la conceptualización y análisis de la creatividad, el enfoque de este trabajo estará basado en el análisis de la creatividad como *proceso:* el *pensamiento creativo*. Este complejo constructo se refiere al conjunto de procesos asociados al manejo de la información, la generación de ideas y la resolución de problemas, en el cual profundizaremos a continuación.

2.2. El pensamiento creativo

Tradicionalmente, la creatividad se ha atribuido a comportamientos ''especiales'' de personas que obtienen logros trascendentes para el resto de la sociedad. Los estudios llevados a cabo en las últimas décadas han desmitificado esta concepción elitista en la que parece que la creatividad está al alcance solo de unas cuantas personas. En esta línea, Smith et al. (1995) sugiere que la cognición creativa no es un elemento unitario con respecto a la cognición estándar. Si bien existen factores que determinan los resultados creativos (personalidad, contexto, etc), los procesos de ideación creativa (pensamiento creativo) en la resolución de problemas se sirve de patrones estándares. La diferencia radica en cómo el individuo combina la información y gestiona su propio pensamiento. Por tanto, podemos decir que el pensamiento creativo es un constructo relacionado con aquellos procesos cognitivos y meta-cognitivos usados por el individuo para generar ideas efectivas y/o alternativas en la resolución de una tarea. Dichos procesos secuencialmente ordenados, podrían llevar al individuo a realizar producciones novedosas adaptadas a un determinado contexto (Zeng et al., 2011). Esta secuencia implica la asociación de ideas o elementos, y extraer nuevas combinaciones para atender a unos requerimientos específicos de una determinada tarea o extraer algo útil.

Dos de los procesos básicos asociados al pensamiento creativo han sido el pensamiento divergente y el convergente. El proceso de pensamiento divergente se refiere a la capacidad de generar variedad de ideas, asociaciones e interpretaciones no convencionales en la resolución de un problema al que se le podrían atribuir varias soluciones; mientras que el pensamiento convergente, hace alusión a los procesos de generación de respuestas lógicas y únicas que requiere un determinado problema (Luft y Bhattacharya, 2015). Los dos elementos son necesarios en los procesos de pensamiento creativo para la resolución de problemas.

Entendemos por resolución de un problema aquel conjunto de acciones empleados por una persona o grupo de personas para resolver una discrepancia o alcanzar un objetivo específico (Shermerhorn, 2013). La resolución de problemas implica la síntesis de información (actual y nueva) y habilidades de razonamiento, además del conocimiento y práctica sobre un domino específico (Tawfik y Kolodner, 2016).

Uno de los aspectos que contribuirían a la conceptualización y a delimitar el término de pensamiento creativo, es cómo este constructo es medido. Si bien una de las características más sobresalientes de la medición de la creatividad en general es la gran diversidad y variedad de instrumentos de evaluación, el modelo de pensamiento divergente de Guilford (1967), uno de los más ampliamente usados en la evaluación de la creatividad, ha ofrecido un enfoque basado en la identificación de varias habilidades intelectuales relacionadas con el pensamiento creativo, y que son desarrolladas a continuación.

2.2.1. Medición del pensamiento creativo a través del pensamiento divergente

Hocevar (1981) identificó varios tipos de medidas de creatividad (inventarios de actitudes e intereses, inventarios de personalidad e inventarios biográficos, etc), entre las que destaca las pruebas basadas en tareas de pensamiento divergente (e.j. Guilford, 1950, Torrance, 1974; Wallach y Kogan, 1965). La investigación psicométrica sugiere que dichas pruebas proporcionan estimaciones útiles del potencial para el pensamiento creativo. Se ha visto que las pruebas de pensamiento divergente son fuertes predictores de comportamientos creativos en la vida real y del rendimiento creativo futuro (Barbot y Said-Metwaly, 2020); y, además, el desempeño en estas pruebas puede evaluarse de manera objetiva (Runco y Acar, 2012). Estas medidas estandarizadas de pensamiento divergente atienden a la capacidad del sujeto de ofrecer múltiples respuestas ante un estímulo determinado (de manera verbal o gráfica) como atribuir distintos usos a un objeto cotidiano común (por ejemplo, un tubo de plástico) durante un tiempo determinado; idear consecuencias a una situación hipotética o imaginaria (e.j. ‘‘*¿Qué pasaría si…?*”); completar un dibujo inacabado o añadir elementos a una figura predeterminada. Esta producción divergente puede identificarse y ser medida a través de cuatro componentes básicos: fluidez, flexibilidad, originalidad y elaboración (Guilford, 1967; Torrance, 1972). *Fluidez* es definida como la habilidad de producir y generar muchas ideas, respuestas alternativas o soluciones a un problema determinado. *Flexibilidad* es la habilidad para usar diferentes categorías de respuesta, lo que implica la capacidad de ver los problemas desde distintas perspectivas. *Originalidad* se refiere a la capacidad para generar ideas y respuestas poco comunes o distintivas en la resolución de problemas. Finalmente, *elaboración* comprende la habilidad de enriquecer ideas previas, añadiendo y/o desarrollando nuevas ideas, elementos o detalles.

La base de lo anteriormente descrito se sustenta sobre el modelo multifactorial de inteligencia de Guilford (1967). Dicho autor trató de clasificar la inteligencia como un conjunto de factores y no como un factor unitario. La estructura del intelecto definida por el autor se basa en tres dimensiones: *operaciones mentales*, *contenidos* y *productos*. De acuerdo a su modelo, los factores fundamentales en la evaluación de los procesos creativos estarían incluidos en las operaciones mentales tales como el pensamiento divergente, el pensamiento convergente y la valoración del sujeto. En base a ello, Guilford diseñó una batería de evaluación del pensamiento creativo que incluía tres tipos de pruebas: a) asignación de usos alternativos en el que el sujeto propone usos no comunes a un ladrillo (Christensen et al., 1960); b) invención de títulos para determinadas historias (Berger y Guilford, 1969); ideación de consecuencias ante una situación hipotética (Christensen et al., 1958). Es una batería bastante amplia por lo que el proceso de aplicación es bastante complejo, es por ello que no es la herramienta más usada dentro del ámbito de la investigación, aunque sí ha sido de gran utilidad en la conceptualización del pensamiento creativo, dando lugar a nuevos enfoques de evaluación psicométrica.

Dentro del paradigma de la identificación psicométrica del rendimiento del pensamiento creativo y sus componentes, el *Torrance Test of Creative Thinking* (Torrance, 1966) es uno de los test psicométricos de evaluación del pensamiento creativo más difundidos. Esta prueba consiste en la evaluación de los componentes clásicos de pensamiento divergente (flexibilidad, fluidez, elaboración y originalidad) a través de dos dimensiones: verbal y gráfica. La dimensión verbal se evalúa según la ejecución de pruebas basadas en preguntas, causas y consecuencias en una situación planteada, modificaciones que haría a un producto para mejorarlo, ''usos inusuales'' atribuidos a un objeto y planteamiento de suposiciones ante una situación hipotética. Por otro lado, la dimensión gráfica es valorada a través de tareas que requieren construir y completar imágenes a través de diferentes figuras (líneas y círculos).

En los estudios que conforman la presente tesis doctoral se usan dos pruebas de pensamiento divergente: el Test CREA. *Inteligencia creativa* (Corbalán et al., 2003), y la *Prueba de Imaginación Creativa* (PIC-N; Artola et al., 2010). Dichas pruebas fueron usadas para evaluar el potencial en pensamiento creativo y cuyas características psicométricas atienden a los distintos componentes de pensamiento divergente.

El *Test CREA. Inteligencia creativa* (Corbalán et al., 2003) es otro de los test más difundidos dentro del ámbito español, el cual consiste en una breve prueba (10 minutos de aplicación) que valora el potencial para el pensamiento creativo a través de la capacidad del sujeto de elaborar preguntas ante un estímulo visual (escena). Los autores consideran la pregunta como un esquema cognitivo en sí mismo que permite no solo la búsqueda de soluciones ante un problema, sino la valoración y evaluación de las ideas generadas, y para descartar y/o ampliar el horizonte de nuevas respuestas. Dicho proceso implica la evaluación crítica tanto de los productos e ideas y la valoración del proceso en sí mismo. Según los autores, el test CREA cuenta con una validez concurrente satisfactoria con la batería de creatividad de Guilford con índices moderadamente altos, y acentuándose en relación a los componentes de fluidez y flexibilidad. Por lo tanto, estos datos sugieren que el test CREA es un instrumento adecuado para predecir el potencial creativo a partir de los componentes básicos de pensamiento divergente.

La *Prueba de Imaginación Creativa* (PIC-N) de Artola et al. (2010) es considerada una de las pruebas más aplicadas en población española (para niños y niñas de entre 8 y 12 años), la cual guarda relaciones con el TTCT (Torrance, 1966) en cuanto al contenido y demandas de las tareas y los dominios medidos. Esta prueba consta de 4 juegos o sub-pruebas (tres verbales y una gráfica) que miden los cuatro componentes básicos de pensamiento divergente. Los autores aportan datos sobre la validez de criterio contrastándola con el Test de Abreación para la Evaluación de la Creatividad (De la Torre, 1996), conocido como TAEC y baremado con población española. A pesar de ser esta última (TAEC) una prueba de componente gráfico, existe una correlación importante entre ambas pruebas, especialmente con las puntuaciones gráficas y puntuaciones totales del PIC-N (dimensión verbal y gráfica).

2.2.2. Importancia del estudio del pensamiento creativo

Dada la trascendencia de la creatividad en el desarrollo social y humano, el conocimiento acerca de su naturaleza se ha convertido en un asunto desafiante para la investigación actual. En este sentido, se ha sugerido que el pensamiento creativo es un proceso que se desarrolla en función al conocimiento y la práctica, y que es imprescindible para afrontar situaciones desafiantes que requieren soluciones adaptativas, tanto a nivel individual como colectivo. Además, podría ser una característica universal responsable de nuestro desarrollo social, cultural y económico propio de la especie humana. De hecho, dado los actuales acontecimientos, y los augurados para un futuro muy cercano, nuestra estructura social y organizativa se enfrentan a desafíos que requieren soluciones urgentes e innovadoras (OCDE, 2010).

Este hecho ha provocado que la educación sea vista como una importante precursora de estrategias que pueden fomentar el potencial creativo de los individuos, así como las competencias necesarias para el desenvolvimiento exitoso en la sociedad actual. El pensamiento creativo podría ser una de las competencias importantes que ayuden al individuo a afrontar los retos de un mundo en constante y apresurado cambio. De hecho, algunos expertos en educación sugieren que el modelo académico mantenido actualmente por las instituciones educativas, es muy probable que sea incapaz de atender a las necesidades concretas de los estudiantes a medio plazo. Es decir, desde la concepción tradicional de la educación (basada principalmente en acumulación de conocimientos) no se asegura que los niños y niñas del presente afronten con las herramientas personales suficientes y adecuadas los retos del futuro (necesidades laborales, tecnología, resolución de nuevos problemas y desafíos). Una educación basada en el desarrollo de competencias de pensamiento creativo podría ayudar a los niños y niñas a adoptar comportamientos más adaptativos al contexto en el que se desenvuelven, además de descubrir, desarrollar y definir sus propios talentos. En definitiva, el pensamiento creativo tal y cómo es descrito por Craft (2008), es un viaje de descubrimiento personal, cuyo vehículo es la imaginación y la curiosidad. Esto podría implicar el desarrollo y/o potenciación de todos aquellos procesos cognitivos y meta-cognitivos que le permitan al individuo adquirir unas competencias personales de generación, evaluación y mejora de soluciones novedosas y adecuadas; unas competencias que le permitan avanzar en su propio conocimiento y expresión de ideas, lo que, a fin de cuentas, repercutiría en el conjunto y en el desarrollo de nuestra sociedad.

2.2.3. Desarrollo del pensamiento creativo

Los esfuerzos por parte de los investigadores no solo han tratado de identificar los procesos que subyacen del pensamiento creativo, además, se ha estudiado su trayectoria evolutiva. Si bien los resultados no son concluyentes, estudios previos sostienen que la evolución y desarrollo del pensamiento creativo fluctúa a lo largo de la infancia. Las investigaciones dentro de este ámbito sugieren la existencia de un desarrollo durante los primeros años, el cual podría darse durante la etapa infantil y el primer año de Educación Primaria. Hoicka et al. (2016) encontraron indicios de la existencia de procesos de pensamiento divergente medibles a partir del primer año de vida. A partir de esta edad y hasta los 6 años, algunos estudios han observado un desarrollo ascendente en el desempeño de tareas de pensamiento divergente (Bijvoet-van Den Berg y Hoicka, 2014; Chae, 2003; Sak y Maker, 2006). Durante edades comprendidas entre los 6 y los 9-10 años, estudios dentro del ámbito del desarrollo no han encontrado indicios de evolución o mejora en los procesos de pensamiento creativo (Darvishi y Pakdaman, 2012; Lin y Shih, 2016; Smith y Carlsson, 1983; Torrance, 1968), lo cual sugiere que existe una interrupción en el desarrollo de los procesos de pensamiento creativo durante ese periodo evolutivo. Dado que el pensamiento creativo, cómo veremos a lo largo de este trabajo, depende en gran medida de factores ambientales o contextuales, esta oscilación a lo largo de la infancia podría ser debida a la influencia o presión del contexto. De hecho, Torrance (1968) sugirió que estos ‘’baches’’ y ‘’saltos’’ observados a lo largo de la infancia podrían deberse a la adaptación del niño a las expectativas del aula (por ejemplo, académicas). Además, postuló que la presión de la interacción social es determinante para mostrar habilidades creativas. Por lo tanto, las situaciones de aprendizaje a lo largo de la escolaridad podrían ser muy importantes en el desarrollo del pensamiento creativo. En otras palabras, el contexto escolar (así como las estrategias metodológicas de aula, interacciones sociales, etc.) podría impulsar o debilitar el desarrollo del pensamiento creativo (Bonawitz et al., 2011; Hoicka y Akhtar, 2011). Además, otros investigadores explican estas oscilaciones observadas en términos de cambios a nivel cognitivo (Lubart y Georgsdottir, 2004; Rieben, 1974). Los estudios del desarrollo indican que los procesos implícitos en el pensamiento creativo están estrechamente vinculados al desarrollo neuro-cognitivo del niño o niña (Ramírez et al., 2017). Es decir, el pensamiento creativo es un constructo complejo que podría estar expuesto a fases críticas a lo largo de la infancia relacionadas con el desarrollo de los procesos cognitivos. Así, por ejemplo, Karmiloff-Smith (1994) sugiere que a lo largo de la infancia pueden darse ciertos "desajustes" de forma que una vez que el niño adquiere nuevas habilidades, se produciría una regresión temporal en la producción creativa. Una vez consolidadas estas habilidades, se restablecen los procesos de pensamiento creativo a partir de los nuevos conocimientos adquiridos.

En resumen, tanto los factores contextuales como los procesos madurativos de las funciones cognitivas parecen ser determinantes en el pensamiento creativo. Sin embargo, debido a la gran cantidad de factores individuales y contextuales que pueden interaccionar durante el desarrollo del pensamiento creativo en la infancia (procesos cognitivos y socio-emocionales, contexto escolar, entorno familiar y cultural), resulta necesario seguir investigando en este ámbito.

2.2.4. Pensamiento creativo en el aula

El pensamiento creativo dentro del contexto escolar es un tema que despierta gran interés en la comunidad científica y educativa. Si bien desde el punto de vista educativo tradicional, como anteriormente se vio, un comportamiento creativo podría ser visto como innecesario e irrelevante para la consecución de los objetivos curriculares (principalmente académicos), los recursos que ofrece el desarrollo del pensamiento creativo a través de estrategias educativas, pueden ser de un beneficio considerable en el proceso de enseñanza-aprendizaje y por ende, en el desarrollo integral del individuo (Baird et al., 2012; Beghetto et al., 2020). Según autores como Corbalán et al. (2003), un alto rendimiento en pruebas de pensamiento divergente se ha relacionado con habilidades adaptativas como flexibilidad ante el cambio; una actitud curiosa y pro-activa hacia el propio aprendizaje, e intereses hacia una amplia gama de temas. Estos aspectos positivos que podrían favorecer el proceso de enseñanza-aprendizaje, también implican otros aspectos no tan favorables para el desarrollo individual. En este sentido, también se ha sugerido que una alta creatividad puede traer consigo comportamientos negativos en cuanto a la socialización y relación entre iguales (falta de comprensión), aburrimiento y desinterés por actividades cotidianas (actividades rutinarias) y/o una actitud crítica y de auto-exigencia desproporcionada. Opuestamente, un bajo rendimiento en pensamiento creativo se ha relacionado con una menor autonomía, una mayor necesidad de entornos más estructurados, y en consecuencia menos flexibilidad ante el cambio (Corbalán et al., 2003).

El estudio del perfil y características del individuo creativo, así como las diferencias individuales en el rendimiento en tareas de pensamiento creativo, a menudo ha llevado a la observación de las relaciones existentes con aspectos curriculares escolares, así como el rendimiento académico. Investigaciones previas han explorado en qué medida el pensamiento creativo podría contribuir en el rendimiento académico, además de en otras habilidades como las capacidades meta-cognitivas o la mejora de las habilidades sociales. Aunque existen algunos estudios previos que han encontrado una correlación positiva entre pensamiento creativo y rendimiento académico (v.g. Escalante, 2005; Niaz et al., 2000; Mourgues et al., 2016; Wang, 2007; Zhang et al., 2018); otros no han encontrado ninguna correlación entre ambas variables (v.g. Arya y Prasad, 2016; Edwards y Tyler, 1965), e incluso otros han encontrado una relación negativa (Anderson et al., 1969). Las discrepancias entre los resultados de estos estudios previos podrían estar asociadas a distintas circunstancias. Por un lado, el modo en que el constructo de pensamiento creativo es medido, y por otro, la medida usada para la valoración del rendimiento académico. En este sentido, Gajda et al. (2017) llevaron a cabo un meta-análisis de 120 estudios (realizados desde la década de los 60) en los que se exploraba la relación entre creatividad y rendimiento académico. Los autores concluyen que la relación entre estos es más fuerte cuando: *a)* la creatividad se mide utilizando pruebas de pensamiento creativo (particularmente pruebas verbales de pensamiento divergente) en comparación con auto-informes; y *b)* el rendimiento académico de los estudiantes se mide mediante pruebas estandarizadas en lugar del promedio de calificaciones (evaluaciones ordinarias).

Por tanto, el estudio del pensamiento creativo también cobra especial relevancia dada la repercusión que podría tener en los procesos de aprendizaje durante la etapa escolar. El conocimiento de su naturaleza debería ser imprescindible en los entornos de aprendizaje para la búsqueda de estrategias que potencien el pensamiento creativo en el aula. Es por ello, que en este trabajo hayamos indagado no solo en el desarrollo del pensamiento creativo como un proceso aislado, sino que, además, hayamos querido profundizar en los procesos cognitivos que podrían estar implicados en el desarrollo de este complejo constructo, entre los cuales podemos destacar las funciones ejecutivas (FFEE), cuya conceptualización pasaremos a tratar a continuación.

2.3. Funciones ejecutivas

Las Funciones Ejecutivas (FFEE) han sido ampliamente estudiadas, especialmente dentro del campo de la Neuropsicología (Jurado y Rosselli, 2007; Suchy, 2009). Se entiende por FFEE aquellos procesos y subprocesos coordinados y organizados para la consecución de una meta. Se trata de un conjunto de funciones que permiten planificar y secuenciar los pensamientos y acciones (guiarlas, supervisarlas y reconducirlas) y adaptarlas socialmente; nos permite seleccionar alternativas y dar respuesta a un estímulo determinado, seleccionando la respuesta más adecuada de manera intencionada para lograr un objetivo. El ser humano se enfrenta de manera cotidiana a situaciones novedosas de distinto grado de complejidad que requieren de un plan o secuencia interna para superarlas. Esto implica, además, procesos de manejo y selección de información relevante para la consecución de un objetivo, al tiempo que descartamos aquella información que ya no sirve o es innecesaria para el fin marcado. Además, estas funciones evitan, entre otros, comportamientos compulsivos, por lo que están implicadas en el manejo emocional y la auto-regulación, con el fin de dar respuestas adaptativas a un contexto atendiendo a unas reglas determinadas (e.j. normas sociales). En resumen, las FFEE conforman un sistema que es capaz de sintetizar información sensorial, emocional y cognitiva proveniente tanto de estímulos externos como internos, para dar respuestas a las exigencias del entorno de manera eficaz, creativa y socialmente adaptada (Díaz et al., 2015; Bryck, y Fisher, 2012; Lezak, 1982).

Desde el punto de vista neuro-anatómico el estudio de las FFEE ha estado relacionado con la corteza prefrontal (CPF). En este sentido, podríamos decir que la naturaleza y correcto funcionamiento de las FFEE es sustentado por una robusta y dinámica red neuronal que conectan distintas estructuras o regiones cerebrales. De hecho, cada proceso cognitivo implicado en las FFEE ha sido relacionado con una región de activación específica, identificándose, al menos, tres circuitos frontosubcorticales diferenciados estructural y funcionalmente: prefrontal dorsolateral, orbitofrontal y cingulado anterior (ver Tabla 1; Díaz et al., 2015, p. 152). Debido a la relación entre función y actividad cerebral, los procesos madurativos de estas estructuras condicionan el desarrollo de las FFEE, siendo la infancia, por tanto, un período crítico para el desarrollo cognitivo y socio-emocional del individuo (Anderson, 2002; Zelazo y Carlson, 2012).

El desarrollo de las FFEE ha despertado gran interés en entornos científicos y educativos ya que se consideran necesarias para el aprendizaje. Estas estarían involucradas en el desarrollo de habilidades cognitivas y sociales como el lenguaje, la resolución de problemas, el razonamiento abstracto y la regulación de las emociones (Boerma, y Blom, 2020; Kotsopoulos y Lee, 2012; Ropovik, 2014; Spruijt et al., 2018). En consecuencia, las FFEE contribuirían a la adquisición de actitudes participativas, activas y reflexivas necesarias en los procesos de enseñanza-aprendizaje. Durante la infancia y adolescencia, un correcto desarrollo de las FFEE permitiría al individuo: a) manejar y gestionar la información; b) autorregularse, adoptar conductas reflexivas y no impulsivas; y c) adecuar su comportamiento a las exigencias del contexto actual.

Tabla 1

Funciones ejecutivas y su relación con regiones o circuitos cerebrales (Díaz et al., 2015, p. 152).

Función	***Región***
Memoria de Trabajo (verbal)	Corteza parietal posterior
Memoria de Trabajo (espacial)	Corteza temporal izquierda
Codificación de la información	Prefrontal dorsolateral
Actualización/ manipulación de la información	Prefrontal dorsolateral
Mantenimiento de la información	Prefrontal ventrolateral
Tareas de alternancia (switching Task)	Corteza frontal inferior y cingulada anterior
Inhibición	Corteza cingulada y orbitofrontal
Planificación	Corteza prefrontal, ganglios de la base y cerebelo.
Toma de decisiones	Prefrontal ventrolateral y orbitofrontal
Función	***Circuito***
Memoria de Trabajo verbal y espacial, la planificación, la secuenciación, la generación de criterios cognitivos y la flexibilidad cognitiva	Circuito prefrontal dorsolateral

Procesamiento de señales emocionales para la toma de decisiones y procesos de inhibición	Circuito orbitofrontal
Monitorización de la conducta la corrección de los errores	Circuito cingulado anterior

2.3.1. Funciones ejecutivas Cool y Hot

Aunque las FFEE se han considerado un constructo de dominio general, estudios sobre las funciones específicas de algunas regiones como la ventral y medial de la corteza prefrontal han apoyado que las FFEE pueden actuar de manera distinta dependiendo del contexto (Bechara, 2004; Damasio, 1994). En base a ello, Zelazo y Müller (2002), propusieron un modelo que diferencia dos aspectos de las FFEE: a) *cool*, que hace referencia a procesos puramente cognitivos que están relacionados con tareas abstractas y descontextualizadas, y asociados con el córtex prefrontal dorsolateral; y b) *hot*, a aquellos procesos derivados de tareas que implican la regulación afectiva y la motivación, y los cuales han sido asociados regiones ventral y medial del córtex prefrontal.

2.3.1.1. FFEE *Cool.*

La Memoria de Trabajo, el control Inhibitorio y la flexibilidad cognitiva son considerados componentes centrales de las FFEE *cool* (Miyake et al., 2000). Miyake et al. (2000) sugirieron que estas tres funciones correlacionaban entre sí mostrando cierta unidad, aunque separables al mismo tiempo como variables latentes. Dichos componentes son descritos a continuación.

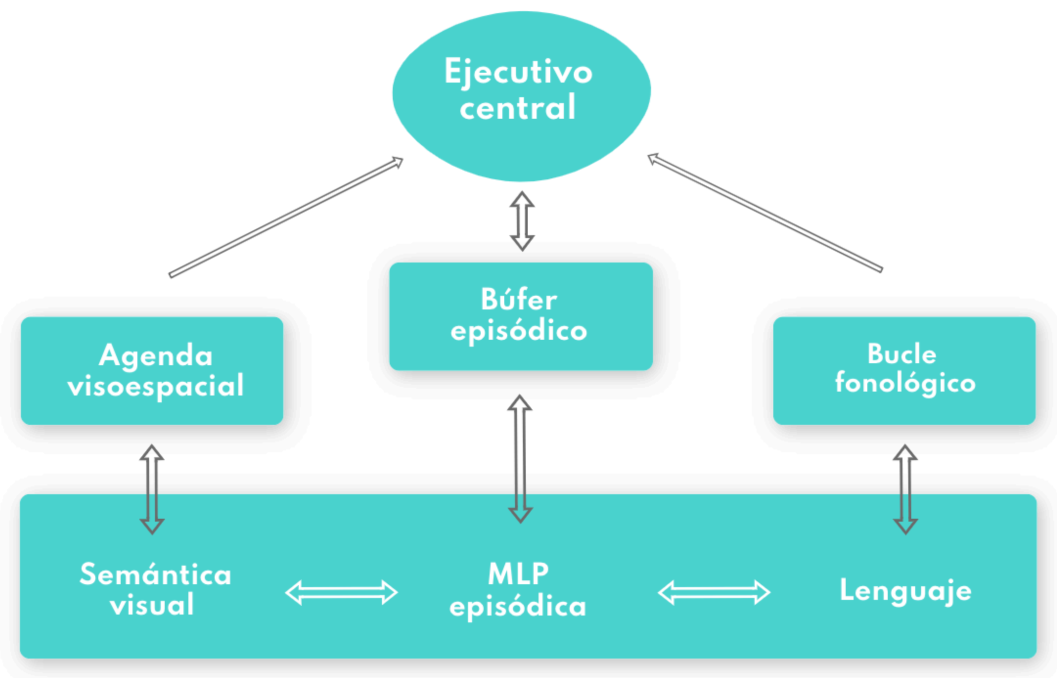
La *Memoria de Trabajo* (MT) es responsable de almacenar y manipular la información de manera temporal y limitada. Este componente ayuda a la codificación y mantenimiento de dicha información, lo cual permite manejarla y transformarla en pensamientos y acciones. La MT tiene un papel fundamental en varias habilidades cognitivas como, por ejemplo, el lenguaje escrito y hablado, o el razonamiento matemático (Baddeley, 2003; Raghubar et al., 2010; Titz y Karbach, 2014).

De acuerdo con el modelo multi-componente de Baddeley's (2000; 2012; 2017), existen al menos cuatro componentes básicos de MT: por un lado, tres sistemas llamados *bucle fonológico*, *agenda visoespial* y *búfer o retén episódico*; y por otro, un sistema superior llamado *ejecutivo central*. El *bucle fonológico* estaría implicado en el mantenimiento activo de la información verbal, e incluye la actualización de la información a través del repaso sub-vocal o habla interna. El segundo gran componente de la MT propuesto en este modelo es la *agenda viso-espacial*. Este sistema se considera análogo al anterior y se encarga de retener información visoespacial, lo cual supondría el mantenimiento de estímulos visuales externos y/o la generación de imágenes internas. Un tercer componente, el *Búfer o retén episódico,* permite la interacción de información de los dos sistemas anteriores (verbal y no-verbal) por lo que contiene episodios o fragmentos integrados de un modo multidimensional. Es considerado como un sistema jerárquicamente superior al bucle fonológico y a la agenda viso-espacial, lo que le otorga una tarea fundamental no solo en el mantenimiento temporal de la información, sino en las relaciones existentes entre MT, la percepción y la memoria largo plazo. Y finalmente, el *ejecutivo central*, el cual es considerado cómo un sistema atencional que ejerce el control sobre los sistemas anteriores. Su función está compuesta de varios procesos como dirigir y cambiar el foco atencional hacia los aspectos más relevantes de una tarea; la coordinación para la realización de varias tareas de manera simultánea y la recuperación y activación de información de la memoria a largo plazo.

Dentro de la literatura sobre el funcionamiento cognitivo, la MT y habilidad de actualización de la información (*updating*) han sido estrechamente relacionados, incluso considerándolos como sinónimos (Diamond, 2013; Garon et al., 2008). La habilidad de actualización (*updating*) es importante para el comportamiento adaptativo del individuo. La actualización es una función cognitiva la cual contribuye al mantenimiento, manipulación y actualización activa de información de la MT necesaria para la ejecución de tareas como la lectura, el cálculo aritmético, la comprensión del lenguaje y/o el razonamiento (Carretti et al., 2005; Deschuyteneer et al., 2006; Palladino et al., 2001; Schmiedek et al., 2009). Por ejemplo, durante una lectura se necesita mantener información relevante, mientras se inhibe información que ya no es necesaria para la comprensión del texto (Palladino et al., 2001). Esta habilidad de actualización también está implicada en la relación entre la representación interna del sujeto con la información del entorno, la cual el individuo tiene que actualizar para que haya una adecuada correspondencia entre las representaciones internas y el mundo externo (Rac-Lubashevsky y Kessler, 2016).

Figura 1

Modelo de Memoria de Trabajo de 4 componentes (Baddeley, 2000)



El *control inhibitorio* es otra de las FFEE *cool* centrales en la que podemos diferenciar, al menos, dos aspectos fundamentales. Por un lado, la *resistencia a la interferencia de distractores* (en el contexto de la atención selectiva), la cual se refiere al control a nivel cognitivo de distractores que interfieren en la realización de una determinada tarea. Y por otro, la *inhibición de respuestas prepotentes*, dominantes o automáticas, de carácter conductual, las cuales no son adecuadas contextualmente o no deseadas, en favor a la generación de respuestas adecuadas a las demandas ambientales o a la ejecución de una tarea (Friedman y Miyake, 2004). Este componente ejecutivo está estrechamente relacionado con el componente ejecutivo de la MT, aunque también se ha asociado con los procesos de auto-regulación conductual (Barkley, 1997).

La *Flexibilidad cognitiva* sería otra de las FFEE *cool* centrales la cual hace referencia al conjunto de procesos mentales que permite al individuo cambiar entre tareas, operaciones o esquemas mentales (Friedman y Miyake, 2004). La flexibilidad cognitiva permite redirigir la atención y focalizarla hacia las demandas ambientales y adaptar las respuestas a nuevas situaciones. Dentro de la literatura, se diferencian dos tipos de procesos implicados en la flexibilidad cognitiva (Fernández et al., 2021): 1) cambio de tarea (*task Switching*), lo cual implica la capacidad de cambiar entre tareas cuando son dadas diferentes instrucciones para estímulos de características cambiantes; y 2) cambio de conjuntos (*Set shifting*), que se refiere a la capacidad de focalizar la atención a diferentes característica de un mismo estímulo de acuerdo a las reglas cambiantes dentro de una misma tarea. Algunos autores sugieren que el cambio de conjuntos (*Set shifting*) es relacionado con niveles más bajos de flexibilidad cognitiva, mientras que el cambio de tarea (*task Switching*) implica procesos más complejos de flexibilidad cognitiva (Bunge and Zelazo, 2006; Dajani and Uddin, 2015).

De estos tres componentes básicos emergen otros procesos denominados de ''orden superior'' que integran diferentes procesos cognitivos y permiten llevar a cabo tareas más complejas. La *planificación* sería una de esas FFEE de orden superior la cual permite al individuo organizar mentalmente una secuencia de respuestas para la consecución de una meta u objetivo. Un correcto desarrollo de las habilidades de planificación permitiría al individuo generar y ordenar secuencialmente las acciones en tiempo y en espacio para la resolución de un problema o tarea, especialmente cuando esta se compone de una serie de pasos intermedios. La planificación se ha asociado estrechamente con otros procesos de orden superior como a la resolución de problemas y razonamiento (Diamond, 2013; Ward y Allport, 1997).

2.3.1.1.1. Evaluación neuropsicológica infantil de las funciones ejecutivas Cool

La evaluación neuropsicológica infantil, específicamente la evaluación de las FFEE dentro del ámbito escolar, centra sus esfuerzos en la mejora de la calidad educativa. Aunque una de las finalidades de la evaluación neuropsicológica dentro del ámbito escolar es la de detectar trastornos de desarrollo para posibles intervenciones de compensación y atención educativa, las investigaciones dentro del ámbito profesional de la educación y de la investigación neuropsicológica también pueden estar enfocadas a la mejora de los procesos de adaptación e integración del alumnado a su medio y entorno social cotidiano (Martín-Lobo, 2015). Así pues, una mejor comprensión de los procesos cognitivos favorecería a la mejora de los procesos de aprendizaje, así como las intervenciones y/o metodologías del aula, entre otras.

Existen diversos tipos de pruebas neuropsicológicas para la evaluación de las FFEE, pudiendo diferenciar entre medidas de evaluación conductual (o escalas de funcionamiento ejecutivo) y test o pruebas de ejecución (Mejía, 2017). Por un lado, entre las medidas de evaluación conductual podemos destacar la escala de *Behavior Rating Inventory of Executive Function* (BRIEF -de 5 a 18 años- Gioia, et al., 2002; Gioia, et al., 2000). Dicha escala permite identificar manifestaciones conductuales de las FFEE a través de la observación (por ejemplo, de padres y madres y/o docentes) dentro del contexto cotidiano del niño o niña. Evalúa componentes tales como el control inhibitorio, el autocontrol emocional o habilidad de planificación. Una de las limitaciones de este tipo de medidas es la subjetividad de los observadores, aunque, en contraste, ofrecen validez ecológica, es decir, una mejor predicción de la capacidad funcional del sujeto en situaciones reales que otro tipo de pruebas no ofrecen. Por otro lado, podemos destacar las baterías de evaluación neuropsicológica en las que, en su mayoría, a pesar de no ser originalmente diseñadas para la medición del rendimiento ejecutivo pueden identificarse sub-tests relacionadas con las FFEE, como por ejemplo el *Cuestionario de Madurez Neuropsicológica Infantil* (CUMANES; Portellano, et al., 2012), o la *Batería de Evaluación Neuropsicológica del Desarrollo* (NEPSY II – 3 a 16 años-; Korkman, et al., 1998). Por otra parte, la *Escala de Wechsler* para Niños (WISC; Wechsler, 2005) aunque inicialmente fue desarrollada para poder obtener una medida del cociente intelectual (CI), también incluye algunos sub-tests que pueden ofrecer información sobre algunos componentes ejecutivos. Por ejemplo, en el WISC-IV los dos sub-test principales de la escala de Memoria de Trabajo (Dígitos -inversos- y Letras y números) pueden proporcinar información sobre la capacidad del sujeto para manipular los contenidos de la MT.

De acuerdo a la clasificación anterior de FFEE *cool (*MT, control inhibitorio, flexibilidad cognitiva y planificación) podemos encontrar algunos test estandarizados de lápiz y papel y pruebas con material manipulativo tradicionalmente utilizados para la evaluación de las funciones ejecutivas.

Así, por ejemplo, el "test de palabras y colores Stroop" (Golden, 1994), ha sido uno de los más utilizados para obtener una medida de uno de los componentes del control inhibitorio. La condición Palabra-Color del test Stroop (en la que se presentan nombres de colores escritos en un color diferente -ROJO-, teniendo el sujeto que nombrar el color en el que aparece escriba la palabra), permite obtener una medida de la capacidad del sujeto para inhibir la dimensión irrelevante del estímulo (el significado de la palabra), al mismo tiempo que se centra en la dimensión relevante para la tarea en curso (el color en el que aparece escrita la palabra). El rendimiento en el test Stroop se ha relacionado con el rendimiento en otros test de lápiz y papel utilizados tradicionalmente como medidas de flexibilidad cognitiva como, por ejemplo, el "Test de clasificación de tarjetas de Wisconsin" o el "Trail Making Test" (Chaytor et al., 2006; Sánchez-Cubillo et al., 2009), o incluso con la Memoria de Trabajo medida a través del sub-test de dígitos inversos del WAIS-III en adultos (Adrover-Roig et al., 2012; Sánchez-Cubillo et al., 2009). No obstante, dichas asociaciones entre estos distintos componentes ejecutivos no siempre son claras, ya que la ejecución de estas pruebas tradicionales de lápiz y papel implican a varios procesos cognitivos. Por ejemplo, Chaytor et al. (2006) encontraron una correlación positiva entre el rendimiento en el "test Stroop" y en el 'Trail Making Test", pero dicha asociación desapareció después de que varios factores (búsqueda visual y velocidad de procesamiento) fuesen controlados en un análisis de regresión múltiple.

La flexibilidad cognitiva ha sido evaluada tradicionalmente con el "Test de Clasificación de Tarjetas de Wisconsin" (WCST; Grant y Berg, 1948) o la *Dimensional Change Card Sorting Task* (DCCS; Zelazo, 2006), esta última relacionada con los procesos de cambio de conjuntos mentales (shifting). La tarea DCCS (Zelazo, 2006) solicita al sujeto atender a las características (color o forma) de un determinado estímulo. El individuo debe cambiar su atención atendiendo a las diferentes características ante un mismo estímulo dependiendo de las reglas, las cuales cambian en cada ensayo de la tarea. Por otro lado, uno de los ejemplos clásicos en la evaluación de la capacidad de cambio de tarea (*task Switching)* es la tarea Número-Letra, en el que el sujeto debe responder a un estímulo de número/letra (por ejemplo, "8B") como vocal/consonante o impar/par, dependiendo de dicho estímulo se ha presentado en la parte superior o inferior de la pantalla (Rogers y Monsell, 1995).

Por otro lado, la evaluación de la MT puede abordarse a través de pruebas específicas de manipulación y actualización (updating) de la información como las tareas basadas en el paradigma *n-Back* (Braver et al., 2001). El procedimiento clásico de esta tarea consiste en presentar una secuencia de estímulos (uno en cada ensayo), y en cada uno de ellos, se requiere al sujeto que indique si el estímulo de cada ensayo coincide con el presentado ''n'' (1, 2 o 3) ensayos antes. La tarea incluiría codificar (el estímulo entrante), asociar (el estímulo con la posición requerida), comparar (el estímulo entrante con el retenido en la posición requerida); posiblemente, descartar o inhibir información irrelevante, actualizar las asociaciones de cada estímulo (es decir, el estímulo presente debe pasar a ser recordado para un posterior ensayo), y eliminar información que ya no es necesaria (Rac-Lubashevsky et al., 2015)

En cuanto a la función ejecutiva de planificación, las tareas más utilizadas han sido las llamadas tareas de las torres (Londres o Hanoi; Bull, et al., 2004; Shallice, 1982). Dichas tareas requieren al sujeto llevar a cabo la proyección mental de una secuencia específica de movimientos para la consecución de un objetivo. El rendimiento en la *Torre de Londres* también se ha relacionado con otros procesos como la MT, ya que el sujeto debe mantener información activa para la secuenciación y ejecución de la tarea.

Por otra parte, algunas de estas pruebas se han utilizado también en estudio con técnicas de neuroimagen y neurofisiológicas, las cuales pueden proporcionar información sobre la asociación entre determinados procesos cognitivos relacionados con las FFEE y patrones de activación cerebral (Berman y Colby, 2002; Langenecker et al., 2004; Rypma, et al., 1999; Verdejo y Bechara, 2010). No obstante, las aplicaciones de estas técnicas no ofrecen resultados conclusivos sobre si dichos patrones de activación están realmente vinculados a las funciones cognitivas evaluadas.

Por otra parte, también es importante señalar que la evaluación específica de las FFEE a puede presentar cierta problemática y limitaciones, entre las cuales podemos destacar: a) *la integridad de la evaluación*. Ningún instrumento evalúa procesos exclusivamente ejecutivos (''puros'') ya que cualquier actividad no ocurre de manera aislada sino que involucra otros procesos y operaciones que pudieran no estar controlándose en dichas tareas (Miyake et al., 2000); b) el *contexto*, controlado por la propia tarea, puede impedir la espontaneidad del sujeto, especialmente en población infantil (Lezak, 1982); y c) la *validez ecológica* de la prueba, la cual hace referencia a la validez del instrumento para predecir la capacidad funcional del sujeto en contextos reales y cotidianos (Bombín et al., 2014).

La evaluación de las FFEE ha supuesto un aspecto relevante en la presente tesis doctoral, tanto para el estudio del desarrollo de los componentes básicos de las FFEE *cool*, como para estudiar la posible relación con el pensamiento creativo. Para estudiar el desempeño ejecutivo de los sujetos participantes en los distintos estudios se ha empleado una batería de tareas informatizadas compuesta por: (1) la tarea *2-back* (Fletcher y Henson, 2001), para evaluar los procesos clave dentro del MT, como el monitoreo, la actualización y la manipulación de la información; (2) una tarea tipo *Stenberg* (Stenberg, 1969) a través de la cual se evalúa la codificación y mantenimiento de la información en la MT; (3) la medida de atención ejecutiva del *Child Attention Network Test* -ANT- (Rueda, et al., 2004) para evaluar el componente ejecutivo de control inhibitorio , y más concretamente la capacidad del sujeto para controlar o suprimir la interferencia de distractores; (4) la tarea *Número-Letra* (Rogers y Monsell, 1995) para evaluar la flexibilidad cognitiva o capacidad del sujeto para cambiar entre tareas o set mentales; y (5) la *Torre de Hanoi* (Borys, Spitz y Dorans, 1982), a través de la cual se evalúa la capacidad del sujeto para planificar. Es decir, organizar y estructurar mentalmente una secuencia de movimientos para dar respuesta a las exigencias de la tarea.

2.3.1.2. FFEE *Hot*.

Tradicionalmente, el estudio sobre las FFEE ha centrado su interés en los aspectos más cognitivos (*cool*), cuyo análisis se ha llevado a cabo en escenarios o contextos aparentemente neutrales (abstractos o descontextualizados). Sin embargo, recientemente ha habido un creciente interés por el estudio de aspectos más afectivos o socio-emocionales (*hot*) de las FFEE, los cuales han sido asociados a la corteza orbitofrontal (Kerr y Zelazo, 2004). Dichos procesos *hot* están relacionados con la toma de decisiones dentro de un determinado contexto. En general, existe un grado de consenso en el ámbito científico que considera las FFEE *hot* procesos de control que se requieren en situaciones que implican un componente motivacional y emocional significativo, o aquellos que provocan un conflicto entre la recompensa inmediata y las metas a largo plazo (Zelazo y Carlson, 2012). La toma de decisiones en situaciones de incertidumbre y la capacidad de demora de la gratificación han sido las FFEE *hot* más estudiadas (De Luca y Leventer, 2008; Peterson y Welsh, 2014). Incluso otros autores defienden que aspectos tradicionalmente relacionados con la cognición social como, por ejemplo, la Teoría de la Mente, la Empatía o la regulación emocional, también podrían considerarse FFEE *hot* (Fernández-García et al., 2021; Happaney et al., 2004; Kerr et al., 2004).

Por otra parte, todos estos aspectos socio-emocionales relacionados con las FFEE *hot* guardan cierta relación con el constructo de Inteligencia Emocional (IE) propuesto por Mayer y Salovey (1997). De acuerdo al modelo propuesto por estos autores, la IE es definida como el conjunto de procesos mentales que permiten al sujeto la regulación emocional y la generación de respuestas adaptativas en un contexto determinado, el cual comprende cuatro habilidades básicas: 1) percepción de las emociones; 2) uso de las emociones para facilitar el pensamiento; 3) comprensión de la emoción; y 4) manejo de las emociones. Dentro de este grupo, los autores distinguen entre aquellas habilidades de razonamiento sobre la emoción (habilidad 1, 3 y 4), y las que implican el uso de la emoción que facilite el razonamiento (habilidad 2).

La *percepción emocional* se refiere a la capacidad del sujeto de percibir e identificar emociones, tanto en uno mismo como en los demás. Esta capacidad incluye estímulos auditivos (voces de personas, música) y visuales (obras de arte) (Ko, 2018; Scherer et al., 2001). Esta habilidad es observada en dos dimensiones: la percepción de la emociones propias y ajenas. Por lo tanto, esta habilidad se extiende desde el reconocimiento individual de las emociones (conciencia emocional) hasta un plano social de sensibilidad afectiva o empatía (Campbell et al., 1971), recepción de afecto (Buck, 1976) y perceptibilidad no verbal (Rosenthal et al., 1979).

El *uso de las emociones para facilitar el pensamiento* permite al sujeto focalizar su atención y procesar la información emocional de manera racional, lógica y creativa para la ejecución de tareas cognitivas como la resolución de problemas o en la toma de decisiones (Brackett y Salovey, 2006).

La *comprensión emocional* implica el análisis de la información a través de procesos cognitivos (lenguaje, razonamiento). Incluye la habilidad para el uso del vocabulario emocional y la apreciación de las relaciones entre la naturaleza de diferentes estados emocionales (Ortony et al., 1988).

El *manejo de las emociones* atiende a aquellas destrezas individuales para la regulación emocional y el estado de ánimo, tanto propio como ajeno. Esta habilidad implica estrategias concretas como el monitoreo, diferenciación y clasificación de las emociones; la modificación de los sentimientos ante una determinada situación, y la capacidad de evaluar la viabilidad de dichas estrategias, con la finalidad de generar una respuesta adaptativa a un determinado contexto (Brackett y Salovey, 2006). El manejo de las emociones desempeña un importante rol en la creación de relaciones positivas, así como entornos más gratificantes y seguros, por ejemplo, los entornos escolares (Valente et al., 2018)

2.3.1.2.1. Evaluación de la Inteligencia Emocional

Uno de los aspectos que ha despertado el interés dentro de la investigación de la IE es el modo en el que esta es medida. Uno de los procedimientos más difundidos dentro de la medición de dicho constructo es el cuestionario de auto-informe, el cual consiste en la presentación de un enunciado verbal en el que el individuo evalúa, generalmente a través de una escala tipo Likert, sus propias habilidades emocionales mediante la autopercepción. Este tipo de medida se diferencia de aquellas otras que evalúan las destrezas emocionales a través de medidas de *habilidad* o *ejecución*, cuya principal característica se basa en la resolución de problemas que llevan implícitos aspectos emocionales; y/o de aquellas pruebas basadas en la observación externa del comportamiento socio-emocional del individuo (Extremera et al., 2004).

Una de las medidas de auto-informe más difundidas dentro del ámbito de la evaluación de la IE es el *Trait Meta-Mood-Scale-48* (TMMS-48) desarrollado por Salovey et al. (1995). Esta escala evalúa la autopercepción emocional del sujeto a través del procedimiento reflexivo sobre la propia experiencia emocional, es decir, sobre el meta-conocimiento de los estados emocionales. Se utiliza una escala de tipo Likert de 5 puntos (1= Totalmente en desacuerdo, 5= Totalmente de acuerdo), y consta de 48 ítems subdivididos en tres dimensiones: 1) *Atención a los sentimientos* (21 ítems), que evalúa la percepción del sujeto de sus propias emociones y sentimientos (Por ejemplo, "*Pienso en mi estado de ánimo constantemente*"); 2) *Claridad emocional* (15 ítems) basada en la manera que tiene el sujeto de percibir sus propias emociones (Por ejemplo, "*Frecuentemente me equivoco con mis sentimientos*"; y 3) Reparación de las emociones (12 ítems), que se refiere a la creencia del sujeto en su propia habilidad para regular emociones, es decir prolongar las emociones positivas en favor a interrumpir o regular las negativas (Por ejemplo, "*Aunque a veces me siento triste, suelo tener una visión optimista*"). Dicha escala posee buenas propiedades psicométricas y capacidad predictiva sobre aspectos como la empatía, la calidad en las relaciones interpersonales (Salovey, et al., 2002), o la resiliencia (Salovey, et al., 1995). Una versión reducida muy difundida dentro del ámbito español es la *Spanish modified Trait Meta-Mood Scale-24* (TMMS-24), adaptada por Fernández-Berrocal et al. (2004). Dicha adaptación mantiene las tres dimensiones de la prueba original, aunque consta de 24 ítems (8 ítems por dimensión) en los que el sujeto tiene que valorar dichas dimensiones sobre una escala de tipo Likert de 5 puntos (1= Nada de acuerdo, 5= Totalmente de acuerdo). La fiabilidad reportada por los autores sería: Atención (0,90); Claridad (0,90) y Reparación (0,86).

La efectividad de evaluación psicométrica de la IE a través del auto-informe ha propiciado la validación de nuevos instrumentos dentro del conjunto de países hispanohablantes. Para el estudio del desarrollo de la IE como factor integrante de las FFEE *hot*, la presente tesis doctoral incluye dos cuestionarios/escalas de auto-informe: el *Test de Inteligencia Socio-Emocional* de Chiriboga y Franco (2001) y la *Escala Básica de Empatía* de Oliva et al. (2011).

El *Test de Inteligencia Emocional* para niños desarrollado por Chiriboga y Franco (2001) incluye 60 ítems distribuidos en 5 dimensiones: 1) *Auto-conciencia emociona*l: percepción y comprensión de las propias emociones (Por ejemplo "*Sé cuando hago las cosas bien*"); 2) *Auto-control*: capacidad de regular las emociones y adaptar los comportamientos a diferentes contextos (Por ejemplo, "*Cuando me enfado lo demuestro*"; 3) *Auto-motivación o Aprovechamiento emocional*: motivación intrínseca para orientar los esfuerzos hacia una meta (Por ejemplo, "*Me siento motivado a estudiar*"; 4) *Empatía*, la capacidad de comprender y reconocer las emociones de los demás (Por ejemplo, "*Sé cuando un amigo esta alegre*"; 5) *Habilidades sociales*: conjunto de habilidades que facilitan y permiten la adaptación al grupo (Por ejemplo, "*Soluciono los problemas sin pelear*". Se utiliza una escala tipo Likert de 4 puntos (0= nunca, 1= a veces, 2= casi siempre, 3= siempre), y según los datos reportados por los autores se observa una validez de constructo aceptable.

Por otro lado, las instituciones educativas también han fomentado el diseño y aplicación de instrumentos de evaluación psicométrica para la mejora de los entornos educativos en favor del buen desarrollo psicológico y competencial del alumnado en distintas etapas educativas. Con esta finalidad fue diseñada y adaptada la *Escala Básica de Empatía* (Oliva et al., 2011) originalmente desarrollada por Jolliffe y Farrington (2006). Esta adaptación, utilizada en la presente tesis doctoral, consta de 9 ítems que son valorados por el sujeto a través de una escala tipo Likert de 5 puntos (1=Totalmente en desacuerdo y 5 =Totalmente de acuerdo) y evalúa dos dimensiones de empatía: 1) *Empatía afectiva* (4 ítems), en la que se valora el comportamiento emocional provocado por los sentimientos de otras personas (Por ejemplo, "Después de estar con un amigo/a que está triste por algún motivo suelo sentirme triste"); y 2) *Empatía cognitiva* (5 ítems), referida a la percepción y comprensión de las emociones de los demás (Por ejemplo, "Casi siempre puedo notar cuándo están contentos los demás"). Dada la relación de la empatía con la conducta pro-social, la *Consejería de Educación de la Junta de Andalucía*, desarrolló distintos instrumentos de evaluación, incluyendo esta adaptación de Oliva et al. (2011), con la finalidad de analizar los contextos educativos y desarrollar estrategias que favorezcan la adaptación social, el desarrollo positivo y competencial (empatía, inteligencia emocional, autoestima, habilidades sociales) del alumnado.

2.3.2. Desarrollo de las funciones ejecutivas

Cómo se ha visto en apartados anteriores, las FFEE permiten la regulación de pensamientos y acciones ante la consecución de un objetivo, además de facilitar la autonomía en el desempeño de tareas y la adaptación de comportamientos al entorno social. Dada la asociación madurativa entre las FFEE y los sistemas cerebrales, los niños y niñas desarrollarán progresivamente todas estas funciones necesarias para hacer frente a retos futuros, tanto a nivel académico como para su correcto desenvolvimiento social y emocional (Blair y Raver 2015). No obstante, los resultados de los escasos estudios previos en los que se ha estudiado el desarrollo de las FFEE *cool* y *hot*, sugieren que estas podrían seguir distintas trayectorias de desarrollo (Fernández-García et al., 2021), y que incluso esta diferenciación entre aspectos ejecutivos *cool* y *hot* solo se observaría a partir de una determinada edad. Así, por ejemplo, estudios previos han observado que el control cognitivo es unitario a los 3 años (Wiebe et al., 2011; Willoughby et al., 2010), y no es a hasta la infancia media y adolescencia que se encuentran evidencias de la existencia de componentes diferenciados (Huizinga et al., 2006; Lee et al., 2013). En este sentido, es importante tener en cuenta que a partir del inicio de la etapa de escolarización obligatoria (a partir de los 6 años en España), las demandas o exigencias del entorno ayudan al niño o niña en la diversificación progresiva de habilidades y al desarrollo de estrategias específicas que implican la inhibición de respuestas, el manejo de la información y la alternancia entre tareas (Chevalier et al., 2019).

Un periodo evolutivo que podría ser de gran importancia para el desarrollo tanto de las FFEE *cool* como *hot* es el comprendido entre los 8 y los 12 años (Leshem, 2016). Los cambios en el sistema cerebral los hacen capaces de distinguir la información relevante de la irrelevante, y aumenta la capacidad de concentración ante la enorme cantidad de información sensorial que ofrece su entorno. Esto permite desarrollar una mayor capacidad de concentración y focalización durante una determinada tarea, y durante períodos más largos (Diamond, 2013; Jolles, 2016). Además, en estudios previos que se ha observado que en este periodo los niños y niñas ya pueden reducir sus conductas impulsivas desarrollando mecanismos de auto-regulación que permiten al niño o niña adaptar su comportamiento y a desenvolverse socialmente (Diamond, 2013; Lawrence et al., 2015; Jolles, 2016; Leshem, 2016). De manera progresiva, a lo largo de esta etapa y durante la adolescencia (Carlson, 2005), los niños y niñas desarrollarán habilidades superiores como la planificación, organización y toma de decisiones complejas, así como el pensamiento abstracto y la regulación emocional (Daniels et al., 2006),

En cuanto a la MT, se han encontrado cambios importantes a lo largo de la infancia media (6-12 años) en el desempeño de tareas relacionadas con la MT, así como en la mantenimiento y actualización de la información de contenido verbal y no verbal (Alloway y Alloway, 2013; Ciesielski et al., 2006; Conklin et al., 2007; Gathercole et al., 2004; Luna et al., 2004; Siegel et al., 1989). Por el contrario, las investigaciones sobre el control inhibitorio han arrojado resultados dispares. Por un lado, se han encontrado evidencias de cambios relacionados con la edad durante el periodo de Educación Primaria (6-12 años) en tareas de control de interferencia (flanker tasks) (Enns y Akhtar, 1989; Mullane et al., 2014; Ridderinkhof et al., 1997; Simonds et al., 2007), aunque hay investigaciones que no han encontrado cambios significativos en este componente ejecutivo desde los 8 (Rueda et al., 2004) o 10 años (Ridderinkhof et al., 1997) hasta la edad adulta.

La infancia es también parece ser un período crucial en el desarrollo de la flexibilidad cognitiva (Buttelmann y Karbach, 2017; Jacques y Zelazo, 2001). Distintos estudios han sugerido cambios relacionados con la edad durante la etapa de Educación Primaria en el desempeño de tareas de flexibilidad cognitiva, específicamente tareas de cambio (Switching tasks) (Cragg y Nation, 2009; Davidson et al., 2006; Dick, 2014), aunque las conclusiones sobre este fenómeno no están claras. Por ejemplo, Dick (2014) sugirió que los niños alcanzaban niveles desempeño en tareas de flexibilidad cognitiva (medida a través del coste por el cambio de tarea) similares a la de los adultos a la edad de 10 años. Sin embargo, otros autores/as han señalado que estas habilidades se desarrollan durante este período y persiste dicho desarrollo hasta la edad adulta (Crone et al., 2004; Davidson et al., 2006).

Por otro lado, la planificación es un componente ejecutivo cuyo desarrollo está también asociado a la edad (Krajenbrink et al., 2020). Las mejoras en esta habilidad de orden superior se han relacionado tradicionalmente con el desarrollo de los FFEE centrales (MT, flexibilidad cognitiva e inhibición) (Diamond, 2013). Aunque esta relación evolutiva con respecto a otros componentes no está del todo esclarecida, sí se han llevado a cabo estudios que confirman, al igual que otros componentes, mejoras en el desempeño en tareas tradicionales de planificación (e.j. Torre de hanoi), los cuales sugieren una mejora relacionada con la edad, concretamente desde el comienzo de la escolarización hasta edades preadolescentes (11-12 años) (Bishop et al., 2001; Matute et al., 2008).

Por último, con respecto al desarrollo de las FFEE *hot*, las primeras manifestaciones del desarrollo de habilidades emocionales, así como la percepción y reconocimiento de emociones, se puede observar a los 3-5 meses (Heck et al., 2018). Después de esto, ocurre una serie de eventos en cascada (por ejemplo, el desarrollo del lenguaje) que conducen a la aparición de habilidades emocionales más complejas como la comprensión o regulación de las emociones, junto con las habilidades sociales (Rosenblum et al., 2009). Desde el campo del desarrollo emocional y social se ha sugerido que la infancia temprana o preescolar (3-5 años) y la infancia media o etapa escolar (6-12 años) son periodos muy sensibles ya que el niño/a está condicionado a los estímulos ambientales que, en última instancia, pueden influir en su desarrollo de manera tanto positiva como negativa (Gee, 2016; Masten y Cicchetti, 2010). Durante este período los niños aprenden a expresar y etiquetar sus emociones y sentimientos, y a utilizarlos como guía para regular su propio comportamiento (Zeidner et al., 2003). Es durante el comienzo de la Educación Primaria que los niños y niñas comienzan a experimentar mejoras en el reconocimiento de emociones, que permanecen estables hasta la adolescencia (Kolb et al., 1992). Otros estudios han sugerido que el desarrollo de otros componentes (conocimiento y manejo de las emociones, y estrategias de regulación) podrían depender del desarrollo individual de habilidades como el lenguaje (Cole et al., 2009), por lo que el desarrollo lingüístico se considera esencial en la adquisición de las habilidades emocionales y sociales básicas (Zeidner et al., 2003). Esto permite al niño/a expresar correctamente sus emociones, generar una comunicación adecuada durante las interacciones sociales y desarrollar comportamientos pro-sociales, así como comportamientos más empáticos (Eisenberg et al., 1987). Al contrario, un comportamiento pro-social pobre ha sido asociado con malas relaciones sociales, comportamientos antisociales y al acoso o agresividad durante la infancia (por ejemplo, Findlay et al., 2006, Mayberry y Espelage, 2007)

2.3.3. Las funciones ejecutivas y el contexto escolar

De acuerdo con lo expuesto hasta el momento, la infancia se caracteriza por el importante desarrollo cognitivo y socio-emocional, y dicho desarrollo es, en gran parte, fundamental en el éxito a lo largo del período escolar. Estudios previos han encontrado una relación entre habilidades cognitivas asociadas a las FFEE y el rendimiento académico (Brock et al., 2009) o las relaciones sociales (O'Toole et al., 2017; Poland et al., 2016). De hecho, estudios en población infantil han relacionado el bajo rendimiento en tareas cognitivas relacionadas con las FFEE con dificultades en el rendimiento académico y el desarrollo de habilidades específicas como la adquisición de vocabulario, las habilidades lectoras o la resolución de problemas (Willoughby et al., 2010). También se han encontrado relaciones entre las FFEE y el desarrollo de habilidades de comunicación y habilidades sociales y emocionales (Beauchamp y Anderson, 2010; Yeates et al., 2007).

Dado el desarrollo prolongado de las FFEE a lo largo de la etapa escolar, y la trascendencia o repercusión de dicho desarrollo en el día a día del individuo, hace de estas funciones un objetivo prioritario en la investigación educativa (van Tetering y Jolles, 2017; van Tetering et al., 2020). Los esfuerzos de las investigaciones en este asunto no solo se han limitado a estudiar el desarrollo aislado de ciertos componentes ejecutivos en un período determinado, sino que además se ha analizado la trascendencia de aquellos factores contextuales que pueden tener algún papel modulador en su desarrollo, así como el entorno familiar (Miller y Halpern, 2014; Noble et al., 2015; van Tetering, y Jolles, 2017), o los entornos escolares (Bagby et al., 2012). En este sentido, estudios de intervención también han mostrado resultados que sugieren que el desarrollo de la FFEE puede ser potenciado a través de determinadas prácticas (Diamond y Lee 2011; Espinet et al., 2013; Holmes et al., 2009). Así pues, las prácticas llevadas a cabo en contextos educativos, así como actividades desarrolladas a través del currículum escolar, podrían ser potencialmente efectivas en el desarrollo y potenciación de las FFEE (Lillard y Else-Quest, 2006; Diamond et al., 2007; Xue et al., 2019).

Por otro lado, se han llevado a cabo intervenciones específicas para el desarrollo de las FFEE en etapa infantil, generalmente para la compensación de dificultades de aprendizaje o trastornos específicos (por ejemplo, TDAH) (Gray et al., 2012; Klingberg, 2007). Por ejemplo, Klingberg (2010) sugirió efectos significativos del entrenamiento de MT en aquellos individuos cuya capacidad de MT pudiera ser un factor limitante para el rendimiento escolar o en ciertas actividades de la vida cotidiana. Además, observó que los efectos del entrenamiento en MT se trasfieren a tareas no entrenadas. En este sentido, en otro estudio llevado a cabo por Klingberg et al. (2005), incluyeron 53 niños con TDAH de entre 7 y 12 años, los cuales fueron entrenados con una tarea informatizada de MT (CogMed©; ver descripción de la tarea en Roche y Johnson, 2014). El estudio mostró que la MT mejoró a través de un entrenamiento específico en niños y niñas con TDAH, y que, además, el entrenamiento específico mejoró el desempeño en otras tareas cognitivas no entrenadas como la tarea Stroop, de control inhibitorio.

En cuanto a los resultados de estudios llevados a cabo con población infantil sin trastornos específicos o dificultades de aprendizaje, también sugieren mejoras a través de este tipo de entrenamiento, tanto cognitivo como socio-emocional (Thorell et al., 2009; Trautwein et al., 2020; Wass et al., 2011). Por ejemplo, Karbach y Kray (2009) observaron mejoras después de aplicar un programa informatizado de entrenamiento de la flexibilidad cognitiva (basado en el paradigma del ''switching task'' o tarea de cambio) en niños de 9 años. Los resultados mostraron mejoras después de cuatro sesiones de entrenamiento (30-40 minutos cada una) en las habilidades implicadas en la tarea de cambio, y en otras tareas que implicaban habilidades cognitivas que no fueron entrenadas, como el control de la interferencia (control inhibitorio) y la MT, tanto espacial como verbal. Sin embargo, a pesar de la eficacia de estos programas diseñados para el entrenamiento de las FFEE, existe una limitación ecológica, es decir, que dichos programas son empleados de una manera descontextualizada. Es por ello que resulta importante estudiar el efecto de otras estrategias relacionadas con aspectos curriculares que pueden ser desarrolladas dentro del contexto escolar. En este sentido, Carretti et al. (2013) examinaron los efectos de un entrenamiento basado en la metacognición y la MT (aplicado durante las horas de clase) sobre la comprensión lectora de 159 estudiantes de entre 9 y 11 años. Los autores encontraron que las habilidades de comprensión lectora mejoraron después del entrenamiento específico, además de mejorar en el desempeño en la tarea de MT (basada en el paradigma de actualización de la información de la MT; Palladino et al., 2001). Por otro lado, St Clair-Thompson et al. (2010) aplicaron, dentro de la planificación curricular, un entrenamiento de la MT basado en el juego (por ejemplo, imaginería, creación de historias) (*Memory Booster*; Leedale et al., 2004) durante 6-8 semanas. Los resultados mostraron una mejora en el desempeño del bucle fonológico y el sistema ejecutivo central (evaluado a través del *Working Memory Test Battery for Children* -WMTB-C-; Pickering y Gathercole, 2001), y las habilidades de aritmética mental.

A pesar de los resultados de estos trabajos previos, son necesarios más estudios que mejoren nuestro conocimiento sobre las FFEE y las estrategias para potenciar o mejorar su desarrollo durante la etapa escolar.

2.4. Pensamiento creativo y funciones ejecutivas *Cool*

Las FFEE se sitúan en el corazón del procesamiento de la información humana y comprenden una amplia variedad de procesos cognitivos básicos (MT, control Inhibitorio y flexibilidad cognitiva) y de orden superior (planificación, resolución de problemas) que permiten a los individuos guiar sus pensamientos y acciones en la resolución de problemas, tener comportamientos adaptados y hacer frente a situaciones novedosas y complejas (Diamond, 2013). Estas características presuponen una relación entre el pensamiento creativo y procesos específicos que pudieran estar relacionados con procesos asociados a las FFEE. Dietrich and Kanso (2010), con la finalidad de identificar correlatos neurales relacionados con el pensamiento creativo, llevaron a cabo un meta-análisis en el que incluyeron 63 artículos en lo que se usaron diversas técnicas de neuroimagen. Una de las conclusiones fue el rechazo a la idea genérica de lateralización cerebral que defiende que el pensamiento creativo se origina en el hemisferio derecho. Además, dichos autores concluyeron que cualquier tipo de actividad creativa (e.j. escritura creativa de historias, resolución de un problema, creación de metáforas o analogías, improvisación musical) o el desempeño de un test de pensamiento creativo (e.j. Tests de pensamiento divergente) estaba promovida por una región específica: el Cortex Prefrontal; región cerebral estrechamente relacionada con procesos asociados a las FFEE. También en la expansión conceptual, proceso relacionado con el pensamiento divergente referido a la ampliación conceptual o afloramiento de nuevos límites a conceptos adquiridos y vital en la generación de ideas novedosas, se ha observado una activación de estructuras prefrontales como el giro frontal anterior inferior izquierdo (Abraham et al., 2012)

Por otro lado, también se ha estudiado la relación entre FFEE y pensamiento creativo a través de estudios basados en el desempeño de tareas específicas, aunque los estudios llevados a cabo en población infantil, especialmente durante la infancia media, son escasos. No obstante, las investigaciones realizadas con muestras de adultos han proporcionado datos que sugieren una contribución positiva de la MT al pensamiento divergente (Benedek et al., 2014; De Dreu et al., 2012; Süß et al., 2002; Zabelina et al., 2019). Dicha asociación es entendida bajo la noción de que la MT facilita el manejo de la información y ayuda a relacionar el conocimiento existente con nuevas ideas y pensamientos (es decir, generar, contrastar y seleccionar ideas) para producir una respuesta adecuada y contextualizada (Lee y Therriault, 2013).

Estudios previos han sugerido una asociación entre flexibilidad cognitiva y pensamiento creativo, aunque dicha asociación podría depender del tipo de tarea empleada (Chi, 1997; Krumm et al., 2018). Los individuos requieren de la capacidad de cambiar flexiblemente entre conjuntos mentales para generar ideas novedosas (por ejemplo, categorías semánticas; Hennessey y Amabile, 2010), aunque no existen evidencias suficientes que constaten que el pensamiento creativo pueda predecirse mediante del desempeño de tareas de flexibilidad cognitiva medida a través de las llamadas switching tasks o tareas de cambio, las cuales requieren al individuo cambiar o alternar categorías o esquemas mentales (ej. Tarea Número-Letra; Rogers y Monsell, 1995). En un estudio con adultos jóvenes, Pan y Yu (2016) evaluaron el pensamiento creativo a través de tres pruebas de pensamiento divergente (tanto verbal como figurativo), y la flexibilidad cognitiva medida a través de tareas de cambio (Switching tasks figurativas y verbales). Sus resultados mostraron asociaciones entre ambos constructos. Resultados contrarios fueron aportados por Benedek et al. (2014), quienes no encontraron asociación entre el pensamiento creativo (medida por la capacidad individual de generación de ideas en diferentes categorías) y la flexibilidad cognitiva (evaluado por la tarea de cambio -Switching task- Número-Letra). No obstante, son escasas las investigaciones empíricas que aporten datos sobre la relación entre flexibilidad cognitiva y el pensamiento creativo, incluidos los de población infantil.

Por otro lado, la asociación entre creatividad y control inhibitorio parece poco clara. Benedek et al. (2012) encontraron relaciones entre fluidez en pruebas de pensamiento creativo (capacidad para producir ideas y respuestas a un estímulo dado) y el control inhibitorio, medido a través de tareas de inhibición de respuestas. Sin embargo, otros estudios no han encontrado asociación entre ambos constructos (Burch et al., 2006; Green y Williams, 1999; Groborz y Necka, 2003; Stavridou y Furnham, 1996), incluso se ha mostrado correlaciones negativas, asociando los bajos niveles de inhibición con altos niveles de creatividad (Carson et al., 2003; Radel et al., 2015). Rotolo (2106) tampoco encontró relaciones entre pensamiento creativo y control inhibitorio medido a través de tareas de flancos (flanker-type task) en las que se evalúa la capacidad del sujeto de controlar la interferencia de distractores, aunque sí encontró asociación entre ambos constructos a través de la tarea N-Back, usada para evaluar la resistencia a la interferencia proactiva, es decir, el control sobre las interferencias de la memoria. Rotolo (2016) explica sus hallazgos sugiriendo que cada proceso inhibitorio (resistencia a la interferencia de distractores y resistencia de la interferencia proactiva) podría estar relacionadas con aspectos diferentes del pensamiento creativo. La capacidad de resistencia a la interferencia de los distractores podría actuar de filtro durante la percepción, lo cual podría influir en la magnitud asociativa que establece el sujeto entre ideas o conceptos durante la ideación creativa; mientras que la resistencia a la interferencia proactiva (inhibición de ideas no originales e inapropiadas) podría permitir evocar asociaciones más distantes para traer a la MT. Por lo tanto, la asociación entre pensamiento creativo y control inhibitorio podría ser positiva o negativa, dependiendo de cómo los constructos son conceptualizados y/o evaluados.

En términos generales, la planificación podría ser necesaria para la ideación creativa, ya que podría implicar la integración de procesos tanto convergentes como divergentes en la resolución de problemas (Osburn y Mumford, 2006). Sin embargo, un amplio número de estudios provienen de ámbitos en los que las habilidades de planificación están vinculadas a las habilidades de gestión, diseño o/y organización (por ejemplo, empresarial; Marta et al., 2005; Mumford et al., 2002). Desde el punto de vista neuropsicológico, la evaluación de las habilidades de planificación son tradicionalmente medidas a través de tareas que evalúan la capacidad del sujeto de estructurar mentalmente una secuencia de movimientos para la consecución de una meta u objetivo (por ejemplo, las tareas Torre de Hanoi y Torre de Londres). Dentro de este paradigma, los estudios con población infantil y pre-adolescente sobre la relación entre pensamiento creativo y habilidades de planificación son escasos y, generalmente, no han sugerido asociaciones entre dichos constructos. Por ejemplo, Krumm et al. (2020) evaluaron una muestra de estudiantes (*n*= 200) de entre 8 y 13 años, la cual fue dividida en dos grupos (altos y bajos) de acuerdo a su rendimiento en dos tareas de pensamiento divergente (Test de Pensamiento Creativo de Torrance; TTCT; 1974; y el test CREA; Corbalán et al., 2003). Los niños de alto rendimiento en pensamiento creativo obtuvieron un mejor desempeño en las tareas de MT (subtest de memoria de trabajo del WISC IV), control inhibitorio (Tarea Stroop) y flexibilidad cognitiva (WCST) que los niños con bajo rendimiento. Sin embargo, no encontraron diferencias significativas entre los grupos en las habilidades de planificación (tarea Laberintos de Porteus; Porteus, 2006). Por otro lado, Sánchez-Macías et al. (2021), evaluaron el pensamiento creativo (medido a través del Test de Pensamiento Creativo de Torrance -TTCT- Torrance, 1974) y varios componentes ejecutivos en estudiantes preadolescentes (*n*= 120), y encontrando correlaciones entre el pensamiento creativo y la flexibilidad cognitiva (medida a través del WCST) y control inhibitorio (Tarea Stroop), pero no encontraron asociaciones significativas entre pensamiento creativo y planificación, medida a través de la tarea Torre de Hanoi.

A pesar de lo descrito anteriormente, son necesarios más estudios que exploren de forma sistemática las relaciones entre pensamiento creativo y distintos componentes de las FFEE, especialmente en etapas críticas del desarrollo como es el periodo comprendido entre el final de la infancia y el comienzo de la adolescencia.

2.5. Aprendizaje cooperativo

El aprendizaje cooperativo es una metodología educativa que parte de la organización del alumnado en pequeños grupos heterogéneos (en cuanto a habilidades y capacidades) para la consecución de unos logros comunes. Es ampliamente aceptado que es una práctica educativa que promueve las interacciones sociales y el aprendizaje entre los alumnos y alumnas en cualquier etapa educativa (Gillies, 2007). El aprendizaje cooperativo se considera una estructura metodológica basada en los principios de cognición social de Vygostky (1978) que considera la interacción social (familia, entorno escolar, etc.) mediadora del aprendizaje y del desarrollo cognitivo y socioemocional. Por tanto, esta metodología rompe con el enfoque individualista del desarrollo, asumiendo que el entorno social es un elemento dinamizante esencial en el desarrollo cognitivo y socioemocional, el cual se da a través del conflicto entre las características individuales del individuo y su entorno social (Gavilán, 2009). Además, la conceptualización del aprendizaje cooperativo como metodología se basa en teorías sociales como la de Watson y Johnson (1972; Teoría de estructura-proceso-resultado), la cual considera que los procesos de interacción son los que determinan los resultados y que los mecanismos para generar dichas interacciones vienen dados por la manera en la que la situación de aprendizaje está estructurada. Dicha teoría se focaliza en el desempeño del docente para la estructuración de los objetivos de aprendizaje para la creación de las interacciones deseadas entre estudiante-estudiante y estudiante-docente. Por otro lado, Johnson y Stewart (2002) sitúan las bases del aprendizaje cooperativo sobre en la Teoría de la interdependencia social. Según los autores, los precedentes de esta teoría los podemos encontrar a principios del siglo XX, cuando Kurt Koffka (uno de los más importantes representantes de escuela gestáltica) propuso que los grupos son entidades dinámicas cuya interdependencia entre sus miembros es variable. Se entiende pues, que los grados de actividad entre los miembros de un grupo varía y puede además modificarse. Más tarde, Lewin (1948), interesado por la resolución de conflictos, introdujo el término de dinámica grupal, basado en la idea de Koffka de que el grupo puede convertirse en un conjunto dinámico e interdependiente en el que cada individuo puede contribuir a un objetivo común. Gracias a ello surge un estado de tensión que genera motivaciones hacia el cumplimiento de dicho objetivo (Johnson y Johnson, 2009). Extendiendo las ideas de Koffka y Lewin, Duetsch (1949) examinó cómo se generan e interrelacionan los sujetos y dan lugar a la motivación hacia el logro de un objetivo. El autor diferenció dos dimensiones de interrelación: 1) *Interdependencia positiva,* la cual se da cuando la interacción de los individuos es empleada en la consecución de un objetivo común. Por lo tanto, un individuo percibe el logro solo cuando el resto de miembros, con los cuales está vinculado cooperativamente, alcanzan sus propios logros; y 2) *Interdependencia negativa*, que se manifiesta cuando el individuo se considera capaz de lograr metas solamente cuando sus competidores no las logran. Es decir, un individuo percibe el logro solo cuando el resto de individuos a los que está vinculado de manera competitiva no alcanzan sus logros. Esto implica que los individuos busquen la consecución de una meta que sea personalmente beneficiosa individualmente, pero perjudicial para el resto; en consecuencia, el logro individual es alcanzado en detrimento del logro del resto de participantes. Este tipo de interrelación suele darse en estructuras educativas *competitivas*. Además, Johnson y Johnson (2014), añaden un elemento a este modelo de interdependencia para definir las estructuras educativas *individualistas* en la que se da, lo que los autores llaman, una *ausencia de interdependencia*. En este caso los objetivos de los individuos no correlacionan. Si bien pueden ser los mismos, la percepción del logro individual no está relacionado con el logro del resto. Es decir, el sujeto busca la consecución de sus propios logros sin importar si el resto los consigue superar o no. Por tanto, el aprendizaje es en beneficio del propio individuo.

El enfoque metodológico del aprendizaje cooperativo se basa en gran medida en el concepto de *interdependencia positiva*. Así pues, esta metodología se centra en la práctica pedagógica que permite a los estudiantes trabajar juntos en pequeños grupos heterogéneos (de entre 4-5 componentes) y de habilidades mixtas, y experimentar la interacción social positiva en favor de la consecución de un objetivo de aprendizaje compartido y común. El aprendizaje cooperativo se basa en el principio de diversidad, y en las necesidades y estilos de aprendizaje individuales (Johnson y Johnson, 2002; Siegel, 2005). La participación y el apoyo a la interacción igualitaria favorece la mejora de las habilidades comunicativas ya que los niños y niñas actúan como promotores de su propio aprendizaje. A través del diálogo los/as componentes de dichos grupos interaccionan expresando opiniones, puntos de vista y ofreciendo hipótesis sobre la tarea en la que están involucrados (Johnson y Johnson, 2004).

2.5.1. Tipos de aprendizaje cooperativo y técnicas cooperativas

Johnson et al. (2014) consideran cuatro tipos de aprendizaje cooperativo que se interrelacionan entre sí: *aprendizaje cooperativo formal*, *aprendizaje cooperativo informal*, *grupos de base cooperativa* y *controversia constructiva*. De esta manera el aprendizaje cooperativo puede usarse para el aprendizaje de contenidos específicos (aprendizaje cooperativo formal), para asegurar el procesamiento cognitivo activo de la información durante el desarrollo de los contenidos (aprendizaje cooperativo informal), y para brindar apoyo y asistencia a largo plazo para el progreso académico (grupos cooperativos base). Además, la cooperación implica la contrastación de opiniones entre los miembros de los grupos cooperativos que provocan conflictos intelectuales llamados controversias constructivas.

Aprendizaje cooperativo formal comprende periodos relativamente extensos (desde una sesión de clase a semanas) para la realización de tareas específicas que implican el aprendizaje mutuo de un determinado contenido, o la realización de una tarea (por ejemplo, llevar a cabo un proyecto de investigación, desarrollar una unidad didáctica, o una obra de teatro). El/la docente plantea una estructura de trabajo específica que implica: 1) planteamiento de logros (a nivel curricular y de habilidades sociales); 2) tipos de agrupamiento que implica la asignación de estudiantes a cada grupo, los roles que cada componente va a asumir, la organización de materiales y la organización del aula; 3) planteamiento de conceptos y estrategias que el alumnado debe dominar y aplicar; es decir, cómo debe completarse la tarea, cuáles son los criterios usados para la evaluación de los resultados, cuáles son las responsabilidades individuales y estrategias personales, y comportamientos que debe adoptar el alumnado; 4) supervisión de los grupos y asesoramiento sobre las habilidades de colaboración y aspectos curriculares; 5) evaluación en base a los criterios prescritos previamente a nivel curricular y de habilidad social.

Aprendizaje cooperativo informal comprende periodos relativamente cortos (desde unos minutos hasta una sesión de clase). Tradicionalmente es utilizado para focalizar la atención en un contenido específico (lectura, actividad o problema) con la intención de motivar durante un periodo corto en el que se estructura de principio a fin una sola sesión de trabajo. Esto ayuda al alumnado a organizar de manera precisa el material, el tiempo y asegurar el logro de la tarea. Normalmente, la sesión está organizada en torno a un asunto específico central (por ejemplo, la explicación del docente sobre una determinada materia o asunto), a continuación de una discusión entre los miembros del grupo en la que se toman ciertas decisiones en función de los objetivos de la tarea, y finalmente, la exposición de las ideas grupales.

Grupos base cooperativos son aquellos grupos heterogéneos que trabajan a largo plazo (por ejemplo, durante un curso escolar o dos) en el que el alumnado se ofrece apoyo mutuo no solo para la consecución de una meta o tarea específica, sino que se brindan el apoyo y motivación hacia el aprendizaje, tanto individual como colectivo, para el logro a largo plazo de un progreso académico en general, incluyendo el bienestar socio y emocional. Por lo tanto, la finalidad es generar una vinculación afectiva que refuerce el compromiso grupal. La sistematización de las relaciones establecidas en el grupo se logra a través de reuniones o asambleas periódicas, por lo que ayuda a la asistencia entre los miembros del grupo en las necesidades diarias de cada componente.

Las *controversias constructivas* surgen cuando las opiniones, así como las ideas y conclusiones de un sujeto entra en conflicto con las de otro, lo cual necesita del consenso mutuo para la presentación de resultados. Johnson y Johnson (2007), sostienen que el desacuerdo es el eje central en la toma de decisiones para el éxito grupal. Esto implicaría la discusión de ventajas y desventajas en una situación determinada con la finalidad de generar soluciones novedosas, es decir, la resolución creativa de un determinado problema o conflicto. Este tipo de aprendizaje cooperativo se estructura en grupos de aprendizaje distribuidos de manera aleatoria para resolver una determinada tarea (redactar un informe o superar un examen). El grupo es dividido en dos en el que cada parte adopta una opinión contraria sobre el tema tratado y deben trabajar en la síntesis y argumentación de los aspectos a tratar. La controversia constructiva se basa en 1) investigar sobre un tema determinado; 2) argumentarlo; 3) participación activa a través del diálogo para defender su argumento; 4) adoptar una postura de escucha y empatía hacia la diversidad de opiniones; 5) la síntesis de las ideas y opiniones del conjunto; y 6) la reflexión sobre el proceso.

En cualquiera de los casos el procesamiento de la información interindividual es un importante elemento. Según Moruno et al. (2012) la información se articulada gracias a las técnicas específicas de gestión grupal, las cuales contribuyen a que los miembros de un grupo cooperativo interioricen estrategias que les faciliten y promuevan sus propios aprendizajes (autonomía, significatividad del aprendizaje, motivación). Los autores diferencian entre: *técnicas cooperativas informales* y *técnicas cooperativas formales*. A través de estas técnicas se diseñan escenarios o situaciones de aprendizaje que fomentan el intercambio de puntos de vista, las interpretaciones y/o la generación de ideas para la resolución de problemas. Las *técnicas cooperativas informales* son aquellas de corta duración (entre unos minutos y una sesión completa). No necesitan de un conocimiento sobre cooperación avanzado y se suelen aplicar en agrupamientos pequeños (2, 3 o 4 componentes), siendo el nivel de interacción bajo. Sin embargo, son técnicas muy estructuradas en las que se pauta exhaustivamente la tarea y están dirigidas a la consecución de metas muy específicas. Se caracteriza por la claridad en el planteamiento e instrucciones. Las *técnicas cooperativas formales* son modelos más complejos cuya duración se extiende durante un período relativamente largo, y requieren de un alto grado de destrezas cooperativas a nivel tanto de la complejidad de la tarea como a nivel de destrezas individuales como la autonomía y auto-regulación (Varas y Zariquiey, 2012).

2.5.2. Elementos del aprendizaje cooperativo

Johnson and Johnson (2009) postularon cinco variables mediadoras del aprendizaje cooperativo: interdependencia positiva, responsabilidad individual, interacción promotora, habilidades sociales e interpersonales y procesamiento grupal.

Interdependencia positiva.

La interdependencia positiva es uno de los pilares del aprendizaje cooperativo basado en la percepción que tienen los sujetos en cuanto a un logro común. El individuo percibe el logro como un éxito grupal, y este se da a través de la contribución e interacción de todos los componentes del grupo cooperativo.

Johnson y Johnson (2005), han identificado al menos dos de tipos estrategias para el fomento de la interdependencia positiva entre los grupos cooperativos: la *interdependencia de resultados* (metas y/o recompensas) y la *interdependencia de medios* (interdependencia de roles, interdependencia de recursos e interdependencia de tareas). La *interdependencia de resultados* (objetivos y/o recompensas) genera motivación y da las circunstancias necesarias que refuerzan la actitud de los miembros de un grupo. Cunado los sujetos se involucran en una situación cooperativa se orienta hacia una meta o recompensa específica. Johnson et al. (2007) sugieren que si no existe interdependencia de resultados (interdependencia de metas y recompensas) no puede darse el fenómeno de cooperación. Según Johnson et al. (2009), aunque la interdependencia positiva de la meta es un elemento suficiente para alcanzar una alta productividad con respecto a enfoques individualistas o competitivos, la combinación de interdependencia de meta y la recompensa tiende a ser más beneficiosa cuando son presentadas de manera combinada. Los autores añaden, que los beneficios de la interdependencia de la recompensa es igual a los producidos por la interdependencia de la pérdida. *La interdependencia de medios* incluye **recursos** que el grupo necesita para la realización de la tarea y la consecución del objetivo; **roles**, con los que se define el modo en el que los miembros del grupo se relacionan e interactúan en términos de funciones (coordinador/a, el lector/a, animador/a, etc), las cuales delimitan las acciones de los miembros del grupo de manera que se complementen (Brewer y Klein, 2006); y **tareas**, que hace referencia a la división del trabajo y que puede ser distribuido entre los miembros del grupo para su realización. Cada parte se superponen y no son independientes entre sí.

Responsabilidad individual.

Este otro elemento es definido como la actitud personal de responsabilidad y compromiso individual hacia el logro grupal, esto implica, además, favorecer el trabajo del resto de miembros del grupo. Por tanto, este sentido de responsabilidad y compromiso debe ser mutuo entre los miembros. Además, la toma de conciencia sobre las necesidades de cada componente es importante para prestarles ayuda o estímulo en el desarrollo de la tarea (Scager et al., 2016). La responsabilidad individual se fomenta a través de la evaluación intergrupal o co-evaluación. Archer-Kath et al. (1994) sugiere que el control de la responsabilidad individual fomenta otros elementos como el grado de interdependencia grupal. Sin embargo, la falta de responsabilidad individual puede llevar a la reducción de las contribuciones individuales y la disminución de la cohesión grupal, lo que puede verse afectado la consecución del logro (Johnson et al., 2009).

Interacción promotora.

La interacción promotora se da cuando los miembros de un grupo cooperativo estimulan y facilitan los esfuerzos de los demás para la consecución de los logros grupales, especialmente cuando aparecen las dificultades. Pujolás (2017), sugiere que la interacción promotora debe llevar a través de la interacción *cara a cara*, facilitando el intercambio de recursos necesarios, así como información y materiales, y promoviendo el procesamiento de la información de manera más eficiente y eficaz.

Habilidades interpersonales.

La contribución al éxito grupal viene dada por las habilidades sociales de los miembros del equipo. El fomento de las habilidades dentro del grupo implica el desarrollo de actitudes de liderazgo, toma de decisiones, generación de confianza y comunicación, y la gestión del conflicto (Echeita, 2012).

Procesamiento grupal.

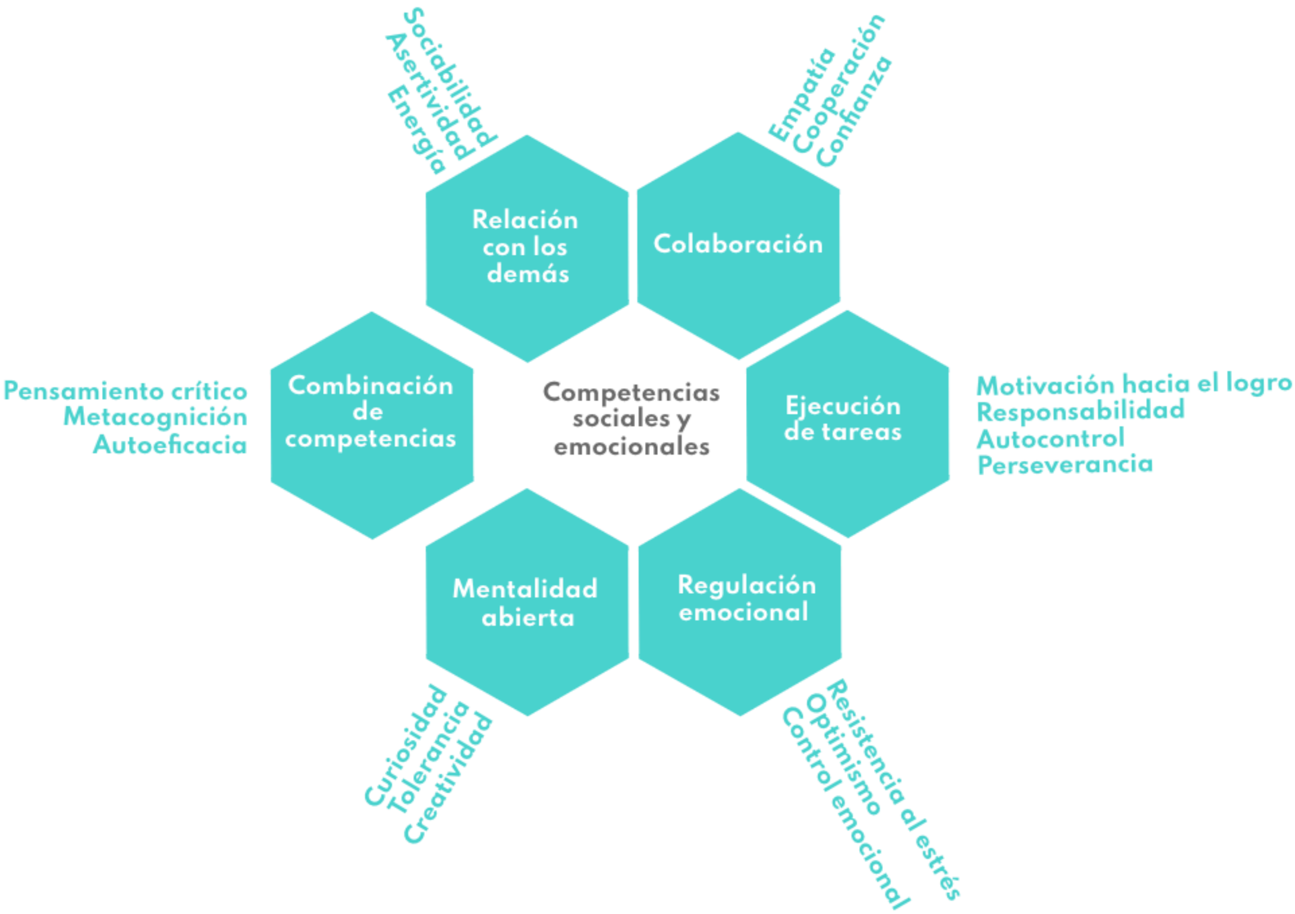
El procesamiento grupal hace referencia al proceso evaluativo y de reflexión grupal mediante el cual los miembros discuten el nivel de implicación y responsabilidad de cada uno, y evalúan qué estrategias han sido más efectivas en el proceso de aprendizaje que se ha llevado a cabo. Es aplicable en distintos momentos del proceso de manera periódica y a través de instrumentos específicos (dosier, hoja de registro, etc.); a lo largo del proceso de ejecución de las tareas o actividades, al final de una sesión, y/o al final del proceso (Iglesias et al., 2017). Según Moruno et al. (2012), la evaluación debe estar basada en el funcionamiento del grupo cooperativo, el desarrollo de las destrezas de cooperación y la consecución de los logros académico.

2.5.3. Aprendizaje cooperativo en el aula de Educación Primaria

Los nuevos retos sociales hacen que educadores/as e investigadores/as dentro del ámbito educativo se planteen la necesidad de incorporar cambios que mejoren los procesos de enseñanza-aprendizaje. En la actualidad, la escuela tiene que hacer frente da fenómenos como el acoso escolar (según el informa PISA 2018, en España ha aumentado en un 2% desde 2015), la exclusión social por razones de distinta índole (racial, religiosa, económica, cultural, entre otras) o la atención del alumnado con necesidades de apoyo educativo (Juárez et al., 2019). Además, las circunstancias acaecidas por la pandemia, de cuya repercusión en el alumnado las autoridades educativas de momento no pueden hacer un balance exhaustivo, han provocado aparentes desigualdades entre el alumnado en cuanto a ritmos de aprendizaje y atención educativa a las necesidades específicas de cada estudiante. Es por ello que exista una necesidad urgente de incorporar prácticas educativas más inclusivas, que generen oportunidades de aprendizaje que no solo enfoquen sus esfuerzos en el rendimiento académico, sino que aporten estrategias motivadoras para el desarrollo cognitivo y socio-emocional del alumnado. Además, las estrategias deben tener como premisas básicas el desarrollo de unas competencias personales que ayuden al individuo a desenvolverse de una manera autónoma, creativa y adaptada al contexto en el que va a desarrollar sus experiencias. La OCED (2019), en respuesta a las competencias sociales y emocionales a las que la escuela tiene que hacer frente sitúa la cooperación, así como la empatía y las relaciones sociales, (además de los procesos cognitivos y la creatividad) como pilares fundamentales para el desarrollo de las habilidades sociales y emocionales para el éxito educativo y el bienestar de los estudiantes (Figura 2). De hecho, Zavala (2018) señala como una problemática generalizada la falta de habilidades sociales en la resolución de conflictos, y resalta la importancia del aprendizaje cooperativo en el desarrollo de habilidades socio-afectivas como indicador de éxito educativo. En este sentido, según el informe PISA de 2018, en el estudio de la influencia del entorno escolar en la vida de los estudiantes, señala que, en general, los estudiantes españoles manifiestan mejores relaciones con sus compañeros y unos vínculos más fuertes con el centro educativo cuando los entornos académicos son cooperativos, mientras que la competitividad entre compañeros/as está negativamente asociados a variables como el sentido de pertenencia al centro escolar. Esto quiere decir que los alumnos y alumnas de entornos más competitivos pueden manifestar menor confianza para compartir sus propias ideas, sentirse incluido, querido, respetado, aceptado y apoyado (Roseth et al., 2008); y además contribuyen al bienestar general y respeto hacia las normas de convivencia (ej. el cuidado de las instalaciones). Roseth et al. (2008), en un meta-análisis en el que examinaron 148 estudios independientes que incluían 17000 participantes pre-adolescentes y adolescentes de 11 países distintos, observaron que las estructuras cooperativas estaban asociadas con un rendimiento académico alto y con relaciones más positivas entre compañeros que las estructuras individualistas o competitivas. Además, la relación positiva entre rendimiento académico y las relaciones positivas entre compañeros estaría asociada a estructuras cooperativas en comparación con estructuras individualistas y competitivas. Los autores sugieren que una de las principales implicaciones de su estudio es que podría existir una proporcionalidad entre estructura cooperativa, relaciones positivas y logro académico; es decir, cuanto más estructurados estén los logros cooperativos las relaciones entre los compañeros serían más positivas, lo que podría repercutir de la misma manera en niveles más altos de logro.

Figura 2

Marco conceptual sobre Competencias Sociales y Emocionales para el éxito y bienestar de los/as estudiantes (OCDE, 2018).

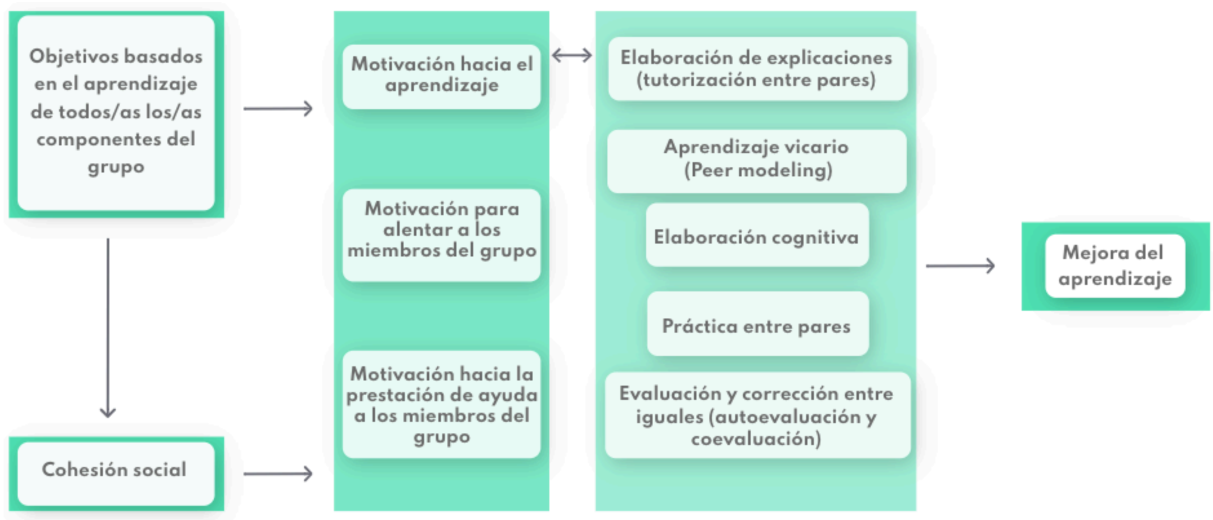


Así pues, el aprendizaje cooperativo podría tener un efecto positivo en el rendimiento del individuo. En este sentido, Slavin (2014) destaca cuatro dimensiones sobre los efectos del aprendizaje cooperativo en los procesos de enseñanza-aprendizaje, las cuales son: la *motivación*, la *cohesión social*, el *desarrollo cognitivo* y la *elaboración cognitiva* (Figura 3). El autor mantiene que el aprendizaje grupal sostenido por los logros y estructuras grupales, así como el aprendizaje cooperativo, podría afectar a los procesos cognitivos gracias a la elaboración cognitiva (ej. manejo de la información) conjunta. Además, la cohesión grupal podría desarrollar la empatía, el apoyo y preocupación entre los miembros del grupo por la consecución de los logros comunes, motivando así a los estudiantes hacia la participación en los procesos cognitivos que mejoran el aprendizaje. En definitiva, los logros grupales propuestos a través de las estructuras cooperativas motivan a los individuos a asumir las responsabilidades propias (independientemente del docente), ayudando a resolver importantes problemas de organización grupal y favoreciendo oportunidades para actividades de aprendizaje cognitivamente apropiadas.

De acuerdo con todo lo expuesto anteriormente, el aprendizaje cooperativo como estrategia metodológica dentro del aula, podría tener un papel importante para el desarrollo del pensamiento creativo y de las FFEE durante la etapa de Educación Primaria.

Figura 3

Modelo de los efectos del Aprendizaje Cooperativo en el proceso de enseñanza-aprendizaje (Slavin, 2014).



2.6. Aprendizaje cooperativo y pensamiento creativo

El estudio del pensamiento creativo en el contexto escolar ha llevado a la búsqueda de estrategias que puedan favorecer su desarrollo dentro del aula (Moeller et al., 2013; Zhu, 2010). Es por ello que las metodologías educativas podrían considerarse un factor importante en el desarrollo del pensamiento creativo a lo largo de la etapa escolar (Besançon y Lubart, 2008; Hong et al., 2009; Soh, 2017). Cropley (1995) destaca algunas características de la práctica docente (por ejemplo, metodologías de aula, o entornos creativos para el aprendizaje) necesarias para favorecer el desarrollo del pensamiento creativo en los estudiantes. Estas características incluyen: promover la autonomía hacia el aprendizaje y la autoevaluación de los estudiantes; ofrecer la oportunidad de generar diferentes acciones para el aprendizaje y hacerlo en una amplia diversidad de condiciones o escenarios; y un estilo de enseñanza cooperativo y social integrador.

El aprendizaje cooperativo ha sido considerado como una práctica educativa asociada al desarrollo de los procesos de pensamiento creativo (Bolen y Torrance, 1978). En este sentido, el aprendizaje cooperativo propone una variedad de estrategias de razonamiento e interacción grupal que implica una amplia diversidad de estilos de pensamiento, lo cual podría ser trascendental para la ideación de soluciones novedosas y originales en la resolución de problemas (Hattie, 2009; Kim y Song, 2012). Qin et al. (2005) llevaron a cabo un meta-análisis (46 estudios) en el que estudiaron el impacto de las estructuras cooperativas (vs competitivas) en la resolución de problemas en un amplio rango de edad (desde pre-escolar a adultos). Los autores identificaron 4 tipo de problemas: *lingüísticos* (los cuales debían de ser resuelto de manera escrita o verbal); *no-lingüísticos* (resueltos a través de símbolos, matemáticas, actividades motoras); *bien-definidos o convergentes* (operaciones y soluciones bien definidas); mal-definidos o divergentes (soluciones abiertas y no definidas). Los resultados de este estudio reportaron que los individuos implicados en estructuras cooperativas superaban a los de estructuras competitivas en los cuatro tipos de problemas. Además, investigaciones que han analizado las relaciones entre pensamiento creativo y estructuras cooperativas han encontrado efectos significativamente positivos en el rendimiento en tareas de pensamiento divergente (ej. CREA Test o TTCT) (Catarino et al., 2019; Marashi y Khatami, 2017; Siew et al., 2017; Sitorus y Surya, 2017). Estos estudios sugieren que las características específicas de estructuras cooperativas (enfoques interdisciplinares, los diseños para la resolución de problemas, los entornos flexibles y abiertos) pueden promover la adquisición de habilidades de pensamiento creativo, a través de la motivación y autonomía de los estudiantes, comprometiéndolos con su propio aprendizaje y entablando relaciones cooperativas (Scott et al., 2004). Kim y Song (2012), sostienen que las estrategias cooperativas permiten al alumnado adquirir habilidades de resolución de problemas, habilidades de pensamiento crítico y creativo desde un enfoque más global, integral y flexible, pudiendo integrar conocimientos de diferentes disciplinas (Matemáticas, Lenguaje, Ciencias, etc); mientras que estructuras individualistas o competitivas desarrollan una adquisición de conocimiento más fragmentado ya que no tienden a relacionar entre materias (asignaturas) o disciplinas, y están enfocada a la resolución de problemas convergentes. Además, cómo vimos en secciones anteriores la percepción de aceptación grupal, y sentirse respetado y apoyado por los miembros de un grupo, podrían mediar en la confianza y libertad para compartir las ideas propias y motivar al alumnado en favor a la mejora de los procesos cognitivos y socio-emocionales que mejoran el aprendizaje (Roseth et al., 2008; Slavin, 2014).

2.7. Aprendizaje cooperativo y funciones ejecutivas

Uno de tópicos de interés actuales dentro la investigación en el contexto escolar es la relación entre las FFEE y las prácticas educativas, siendo el objetivo central el correcto desarrollo del individuo a lo largo de la infancia (Diamond y Lee, 2011). En este sentido, toman especial relevancia aquellas prácticas que implican una interacción social positiva, lo cual podría tener un importante impacto en el desarrollo cognitivo y socioemocional del alumnado (Bohlmann y Weinstein, 2013; Poulou, 2014; Staiano et al., 2012).

Cómo se expuso anteriormente, el aprendizaje cooperativo es una práctica educativa basada en la interacción social que ha sido asociada a relaciones más positivas entre compañeros, al contrario que estructuras con enfoque individualista o competitivo

(Roseth et al., 2008). La generación de vínculos afectivos e interacciones sociales positivas dentro del aula promueven estados emocionales que podrían favorecer el flujo de información y la generación de respuestas más adaptadas a situaciones contextuales (Willis, 2007). Por el contrario, las situaciones de estrés generadas por interacciones negativas (incluyendo padres, docentes y/o compañeros) podrían tener efectos negativos en el desarrollo cognitivo del alumnado (Berry, 2012; Blair et al., 2015). En este sentido, investigaciones centradas en el análisis de los entornos escolares y el impacto sobre el desarrollo de las FFEE destacan la importancia del clima emocional y psicológico (Hamre y Pianta, 2007; Hamre et al., 2013; Hatfield et al., 2013; Veraksa et al., 2020). Por ejemplo, Hatfield et al. (2013) sugirieron que aquellos niños y niñas de entornos en los que existía un apoyo emocional alto (por ejemplo, atención sensible y cálida del docente, o reconocimiento de las opiniones e ideas del alumnado) reducían el estrés y veían favorecido su desarrollo cognitivo, frente a aquellos niños de entornos caracterizados por menos apoyo emocional. Según los autores, las interacciones positivas dentro del aula (docente-alumnado y/o entre compañeros) podrían favorecer situaciones de aprendizaje más participativas y motivadoras hacia el propio aprendizaje y, por ende, un entorno más favorecedor para el desarrollo de las FFEE (Williford et al., 2013). Así pues, una relación de confianza entre compañeros y la predisposición del docente para la creación de entornos de aprendizaje bien estructurados y cooperativos; positivos emocionalmente y estimulantes, podría ser un factor esencial en el desarrollo de las FFEE dentro del aula, tanto a nivel cognitivo como socio-emocional (de Wilde et al., 2015; Rimm-Kaufman y Wanless, 2012; Vandenbroucke et al., 2018). Por el contrario, las relaciones negativas y/o conflictivas, las cuales generan situaciones de estrés y son consideradas como pobres afectivamente, han sido relacionadas con las actitudes menos cooperativas entre el alumnado y una predisposición negativa del niño hacia el aprendizaje, (Birch y Ladd, 1997).

Así pues, el tipo de interacción generada por estructuras cooperativas podrían ser un importante predictor de las habilidades de aprendizaje (Sabol et al., 2013) y del rendimiento ejecutivo (a nivel cognitivo y socio-emocional) desde edades tempranas (Bodrova et al., 2006; Hamre et al., 2013; Rimm-Kaufman et al., 2009; Staiano et al., 2012; Weiland et al., 2013). Además, dichas interacciones, también han sido relacionadas con mejoras en procesos cognitivos y socio-emocionales como la resolución de problemas, el pensamiento creativo, o las habilidades sociales, en comparación con aquellos sujetos que aprenden a través de metodologías o estructuras individualistas o competitivas (Beghetto, 2016; Fawcett y Garton, 2005; Pai et al., 2105; Segundo et al., 2020). Una estructura cooperativa puede ayudar a generar nuevas preguntas y situaciones, que animan a los alumnos a pensar de forma crítica y creativa sobre cómo resolver un determinado problema. El intercambio de ideas, la comparación y su confrontación, potenciarían el conflicto cognitivo y motivarían en beneficio del desarrollo individual (Gawe, 2007; Johnson et al., 2000). Asimismo, la estructura de trabajo cooperativo contribuiría a la capacidad de los estudiantes a pautar y secuenciar el trabajo conjunto; a adaptarse a las demandas cambiantes y a actuar de forma menos impulsiva (así como una mayor capacidad de control inhibitorio), y a la aplicación de diferentes habilidades cognitivas tales como analizar, razonar, evaluar y/o crear (Diamond 2006; Richhart y Perkins 2008).

Si bien lo mencionado anteriormente sugiere unos efectos positivos de los entornos educativos (en especial los basados en aprendizaje cooperativo) sobre ciertos procesos cognitivos y socio-emocionales, los estudios que evalúan los componentes específicos de las FFEE (*cool o hot*) en población infantil son escasos. Algunos autores sugieren que la capacidad de retención y manipulación de la información en la MT parece ser esencial para desarrollar estrategias dirigidas a la consecución de los objetivos (Diamond 2006; Luna et al., 2004). Esta idea podría ser congruente con estudios que sugieren que el rendimiento de la MT puede verse influenciado por las interacciones sociales en la escuela durante la infancia (de Wilde et al., 2015; Vandenbroucke et al., 2018). Por otro lado, Booysen y Grosser (2014), sugirieron efectos positivos en habilidades relacionadas con las FFEE, medidas a través de tareas que implicaban la adquisición y aplicación de procesos cognitivos y meta-cognitivos; según los autores, estrategias relacionadas con la MT, control inhibitorio y flexibilidad cognitiva.

A pesar de estas evidencias empíricas sobre los efectos del aprendizaje cooperativo en las habilidades cognitivas y socio-emocionales, son necesarios más estudios que exploren el papel mediador de las metodologías de aula (como el aprendizaje cooperativo en comparación con el aprendizaje individualista) en el desarrollo de las FFEE (*cool* y *hot*) en niños y niñas durante la etapa de Educación Primaria.

3

Justificación y Objetivos

Como se ha visto a lo largo de la introducción general, el pensamiento creativo es un constructo complejo imprescindible en la ideación y resolución de problemas relacionado con una amplia gama de dimensiones individuales. Además, dada su importancia en el desarrollo social y adaptativo del ser humano, el conocimiento sobre su naturaleza, así como los procesos cognitivos que subyacen a la ideación creativa, se ha convertido en un asunto de especial interés dentro del ámbito científico y educativo.

Igualmente, las FFEE implican procesos cognitivos que tienen una gran importancia en el desarrollo social y adaptativo de los individuos. De hecho, desajustes en dicho desarrollo podrían implicar dificultades en la adquisición habilidades necesarias para el aprendizaje y la adaptación al contexto social. A pesar de que la evaluación neuropsicológica de las FFEE durante la etapa infantil es una práctica cada vez más extendida, la investigación de su desarrollo y el papel modulador de los factores del entorno escolar sigue siendo necesaria.

Además, a pesar del conocimiento actual en cuanto al desarrollo y las relaciones entre el pensamiento creativo y las FFEE *cool* y *hot*, tanto los cambios de desarrollo como su interacción durante la etapa escolar siguen siendo foco de interés entre investigadores y educadores.

Por otro lado, también existen datos en la literatura científica que indican que el contexto escolar es un factor que podría ser trascendente en el desarrollo evolutivo de los individuos; pues es un espacio en el que confluyen las características individuales y los distintos agentes o factores que interaccionan con estas. Es por ello que, tanto desde el ámbito de la investigación como de la educación, resulta necesario prestar una especial atención a los aspectos que modulan dichos contextos, entre ellos, la práctica docente. En este sentido, la práctica docente se caracteriza por el uso de unos determinados recursos, entre los que se encuentran aquellos relacionados con la metodología de aula. Dichas metodologías, básicamente, actúan sobre dos aspectos fundamentales: a) cómo los contenidos curriculares son desarrollados; y b) cómo las relaciones interpersonales dentro del aula son gestionadas. Este último, como se ha visto con anterioridad, podría mediar el desarrollo de habilidades básicas relacionadas con las FFEE y el pensamiento creativo, lo cual podría repercutir en otros procesos necesarios, ya no solo para el aprendizaje, sino para aspectos relacionados con un correcto desenvolvimiento en la vida cotidiana y en el bienestar personal del individuo.

Por otra parte, como se ha visto a lo largo de la introducción, son escasos los estudios previos en los que se ha estudiado la relación entre el pensamiento creativo y las FFEE en un período especialmente crítico como es la transición entre la infancia y la pre-adolescencia, siendo aún más escasos aquellos en los que además se investigue el papel modulador de las variables del entorno escolar (por ejemplo, la agrupación del alumnado, el tratamiento de los contenidos o las metodologías de aula).

Por todo lo descrito con anterioridad, el ***objetivo general*** de la presente tesis doctoral consistió en estudiar el desarrollo y posible relación entre el pensamiento creativo y las funciones ejecutivas a lo largo del tercer ciclo de Educación Primaria (de los 9 a los 12 años de edad), teniendo en cuenta el papel modulador del aprendizaje cooperativo como metodología de aula en comparación con el aprendizaje individualista. Para la consecución de dicho objetivo general se llevaron a cabo cuatro estudios con los siguientes ***objetivos específicos***.

Estudio 1. *Promoting children's creative thinking through reading and writing in a cooperative learning classroom*

1. Investigar si el pensamiento creativo en niños y niñas de 5º curso de Educación Primeria podría ser potenciado a través de un programa estructurado de actividades de lecto-escritura implementado en al aula través de la metodología de aprendizaje cooperativo.
2. Examinar la correlación entre las mejoras en pensamiento creativo (medido a través del Test CREA) y el rendimiento académico, medido a través del promedio de calificaciones escolares.

Estudio 2. *Development of executive functions in middle childhood and the mediating role of Cooperative Learning: a longitudinal study.*

1. Examinar longitudinalmente el desarrollo de distintas FFEE *cool* (memoria de trabajo, control inhibitorio, flexibilidad cognitiva y planificación) y FFEE *hot* (inteligencia emocional y empatía) en niños y niñas durante el tercer ciclo de Educación Primaria (de los 9 a los 12 años edad).
2. Determinar si la metodología de aula (aprendizaje cooperativo vs aprendizaje individualista) podría mediar en los posibles cambios de desarrollo observados en las FFEE *cool* y *hot* durante este periodo evolutivo.

Estudio 3. *Creative thinking development in middle childhood and the Cooperative Learning contribution*

1. Examinar longitudinalmente el desarrollo del pensamiento creativo en niños y niñas durante el tercer ciclo de Educación Primaria (de los 9 a los 12 años).
2. Estudiar el papel mediador de la metodología de aula (aprendizaje cooperativo vs aprendizaje individualista) en el desarrollo del pensamiento creativo a lo largo de este periodo evolutivo.

Estudio 4. *Creative thinking skills and executive functions at late childhood*

1. Estudiar la relación entre FFEE *cool* (memoria de trabajo, control inhibitorio, flexibilidad cognitiva y planificación) y el pensamiento creativo en niños y niñas con los que se ha utilizado distintas metodologías de aula (aprendizaje cooperativo vs aprendizaje individualista) durante el último ciclo de la Educación Primaria.

4

Estudios empíricos

E1

Promoting children's creative thinking through reading and writing in a cooperative learning classroom

Segundo Marcos, R. I., López Fernández, V., Daza González, M. T., & Phillips-Silver, J. (2020). Promoting children's creative thinking through reading and writing in a cooperative learning classroom. *Thinking Skills and Creativity*, *36*, 100663. https://doi.org/10.1016/j.tsc.2020.100663

Abstract

The objectives of the present study were to investigate whether students' creative thinking can be enhanced through a structured program of reading and writing activities in the context of a cooperative learning classroom, and to test for a possible correlation between improvements in creative thinking and improvements in academic performance. Sixty fifth-grade students from a primary school in the south of Spain participated over two months: half received reading and writing activities in a cooperative learning classroom (experimental group, n=30), and half received the standard fifth-grade reading and writing program (control group, n=30). Creative thinking was assessed through a divergent thinking task (CREA Test; Corbalán et al., 2003), and Grade Point Average (GPA) was used as index of academic achievement. The results revealed a significant increase in creativity scores in the experimental group as compared with the control, and a moderate positive correlation between creative thinking and academic achievement. The present findings are consistent with the idea that creative thinking (divergent thinking) can be enhanced with reading and writing activities implemented through cooperative learning in school-age children.

Keywords: Creative thinking, divergent thinking, Cooperative learning, Academic achievement, Literacy.

Introduction

The study of creative thinking in school-age children sparks great interest for researchers and educators in the possibility that typical classroom learning activities like reading and writing, when implemented in a nurturing context, could promote cognitive and creative skills (Flower et al., 1990; Squire, 1983; Wang, 2012). This question is especially important as studies of children's learning and education increasingly support the idea that creative thinking—including such skills as idea generation, or *divergent thinking*—occur not independently from learning activities, but through them (Alencar, Feldhusen, & Widlak, 1976; Alfonso-Benlliure, Meléndez, & García-Ballesteros, 2013; Cheng, 2019; Gu, Dijksterhuis, & Ritter, 2019; Kim, Choe, & Kaufman, 2019).

Divergent thinking, which is often measured by tasks of idea generation, is considered an important predictor of creative thinking (Runco & Acar, 2012). Previous studies have reported qualitative measures to describe how structured classroom activities in reading and writing can encourage students in idea generation and creative productivity (e.g. Wang, 2012). However, there are scarce empirical studies that demonstrate a relationship between structured reading and writing activities (implemented through specific classroom methodology) and creative thinking in children.

Creative thinking is a process of association and combination of elements. The ability to perceive, understand and generate new ideas from a problem and transmit the results is inherent in the generative and adaptive nature of human thought (Wang, 2012; Ward, Smith, & Vaid, 1997). Craft (2000) highlights creativity in terms of thinking about the school context (problem solving, novelty and problem finding) as a process which involves imagination, posing questions and play. By promoting creativity and imagination children develop skills that are useful for exploring and understanding their own world, and helping them to create new concepts, modify or expand existing ideas (Duffy, 2005). Creative thinking implies observing and analyzing a problem from different perspectives, formulating new solutions and reaching new cognitive entities that did not previously exist (Hensley, 2020; Ward et al., 1997). This categorization and conceptualization is a creative process in itself which plays an important role in development. In fact, developmental studies in school contexts have shown that the learning environment (e.g. influence of pedagogy, organizational climate) has a significant impact on creative thinking performance (Besançon & Lubart, 2008), which is essential for the long-term success of individuals (Perry & Karpova, 2017). Fostering thinking creatively is a way through which children express their thoughts and emotions, create new meanings and knowledge, solve problems and gain self-esteem (Duffy, 2005). Yi, Hu, Plucker, and McWilliams (2013) showed a significant relationship between creative thinking and the school context, but that relation became weaker over time. Their results showed that creative thinking scores were significantly higher in children of primary school than those of children in middle school. The authors interpreted that the creative organizational climate was determinante at earlier stages of education and that the demands of the curriculum and the characteristics of the pedagogical process may change over the years. A study carried out by Gajda (2016) in which she examined 1106 students from different educational stages, observed that academic performance and creative thinking correlated strongly at earlier ages, while in older students this relationship decreased. In the early years, generally curricula focus more on skill and cognitive process development while respecting children's spontaneous activity, whereas students at later stages are faced with academic requirements that can restrict creative activity (e.g. final tests, university access). Therefore, we know that the school context is an important place of development of creativity, but the question is how it is promoted in the classroom.

The classroom has an important role as the context for daily structured learning activities through different methodologies. One of the key pedagogical methodologies that is thought to enhance creative thinking in students is Cooperative Learning (CL). A basic premise of CL is that it must present methods for cooperative work including simultaneous "face to face" interactions between students (Johnson & Johnson, 2002;

Pujólas, 2010). That is, the activities undertaken by the students must be structured to nurture the learning that arises from communal reflection, the exchange of ideas, shared critical analysis and continuous dialogue with the aim of accomplishing a common goal. CL encourages students to help each other through peer inquiry and explanation. These types of interactions may promote the ability to generate and explore ideas—which is considered a key characteristic of creative thinking. Although this type of methodology has been associated with improvements in students' academic, personal and social development, there is little empirical data that relates them to improvements in creative thinking (Ghufron & Ermawati, 2018; Orora, Keraro, & Wachanga, 2014).

Purpose of the study

The primary objective of the present study was to investigate whether students' creative thinking can be enhanced through a structured program of reading and writing activities, based on the educational curriculum and implemented in the classroom through CL. The secondary objective was to test for a possible correlation between improvements in creative thinking and academic performance as measured by GPA.

Measures of creative thinking

The measurement of creativity is one of the most controversial issues within the field of psychology. The large number of creativity measuring instruments is an indicator of how complex it is to define and measure the different aspect of this construct (Said-Metwaly, Kyndt, & Noortgate, 2017). Creativity measure have been treated from different approaches to measure critical components for creative performance, from cognitive processes to environmental factors (Said-Metwaly et al., 2017), including divergent thinking tasks, biodata and personality questionnaires or interest and attitude inventories (Clapham & King, 2010; Clapham, 2004; Hocevar, 1981). A study conducted by Said-Metwaly et al. (2017) identified four different approaches in the evaluation of creativity: process (e.g. divergent thinking, problem solving), person (e.g. personality and attitude), product (outcome or performance) and press (environment).

Guilford (1975) considered creativity to be the result of a combination of two types of cognitive operations or thinking abilities: convergent and divergent thinking. Either one can be prominent depending on the moment of the creative process (Alfonso-Benlliure et al., 2013). Convergent thinking is an analytical processes in which the information is organized in a specific logical way to give an unequivocal solution for a problem. Instead, divergent thinking is used in open problems in which the previous knowledge is activated to generate alternative and logical responses. For the purpose of the present study we examine creative thinking as assessed through divergent thinking (idea generation). While creative thinking and divergent thinking are not synonymous, (e.g., divergent thinking may lead to ideas that are original ideas but not considered creative), divergent thinking has been shown to be a reliable predictor of a child's potential for creative thinking (Runco & Acar, 2012).

Reading, writing, and creative thinking

Language is strongly linked to the creative processes. It is a continuous and reciprocal relationship developed during childhood that might be reflected to some extent in reading and writing ability (Gentner & Goldin-Meadow, 2003). In fact, there exist aspects that promote creativity which could be developed through reading and writing activities and practices (Wang, 2012). As for writing, this is a process that involves cognitive and metacognitive skills. Hacker, Keener, and Kircher (2009) considered writing as applied metacognition in which one reconstructs concepts or associates them to generate new ideas and convert them into new texts (history, poetry, letter, comics, etc.) (Bayat, 2016). From a cognitive perspective of writing, the production of written text is considered itself as a set of actions related to problem solving. In this sense writing is a goal-directed action that encourages the writer to modify the objectives as the task advances (Larkin, 2009). In contrast with other activities, reading and writing allow a kind of freedom, an ability to communicate ideas, self-discovery and attention to the individual which are some features necessary to develop creativity (Danesh & Nourdad, 2017).

Although the mechanisms that facilitate creativity are not completely clear there is empirical evidence of the relationship between writing and reading skills and creative thinking. A study conducted by Ritchie, Luciano, Hansell, Wright, and Bates (2013), reported significant correlations between reading level and scores on creativity measures. The authors argued for the positive effect of reading on creative thinking by considering that reading nurtures mental representations useful for manipulation during creative thinking. Therefore, they thought that exposure to writing and reading activities would impact children in both language skills and creative thinking performance. Wang (2012) confirmed this idea when she found that people who spend more time writing and reading scored significantly higher on creative measures. Thus, reading and writing skills seem to have a facilitating effect on student’s creative thinking.

In the school environment, reading and writing are not the only factors that could influence children's creative thinking. Indeed, creative thinking occurs in an ecological learning environment in which the teacher’s behavior and that of the children (and interactions between them) play a role in creative thinking development (Craft, 2000). One issue in any education practice is how the teacher can design the learning environment such that it supports creative thinking. Teachers sometimes implement traditional strategies to meet curricular demands and performance expectations (e.g.

high-stakes testing). These practices are commonly insensitive to diversity and have a negative effect on student performance (Kozlowski & Si, 2019). 'Student-centered' teaching strategies (e.g. promoting and stimulating enjoyment and active participation) could be a way to promote equity and creative possibilities in children (Mohd, Omar, Turiman, & Osman, 2012). In a study on learning environment factors, Grogan and Martlew (2014) suggested that when teachers develop structured activities in the classroom while also offering the students autonomy in choice and control of their own learning, creative outcomes are enhanced. In an exploratory study carried out by Chan and Yuen (2014) by interview of primary school teachers, the authors described how a safe classroom atmosphere as promoted by teacher behaviors and activities, allowed students to take risks, to make mistakes and expand new ideas necessary creative outcomes. This is consistent with the idea that children need an open space for sharing new ideas in order to improve upon them (Craft, 2000). A learning environment in which children feel their ideas are meaningful increases their motivation, as well as their perception of and confidence in their own creative ability (called 'creative self-efficacy'). A positive social environment (Chang, Wang, & Lee, 2016) including the teacher's behaviors (e.g., expectations about children's creative thinking, promotion of creative self-efficacy in children) can affect the students' intrinsic motivation, and help them deal with tasks that require creative thinking (Karwowski, Gralewski, & Szumski, 2015). Studies based on contextual analysis suggest that there is a relationship between creative performance, students' perception of their own creative potential and teaching behaviors (Beghetto, 2006; Hartley, Plucker, & Long, 2016; Soh, 2017). Therefore, creative thinking can improve in children through certain educational practices, with the teacher's behavior being one important factor in addition to teaching practice, promotion of creative environments and design of creative programs (Kerem, Kamaraj, & Yelland, 2001; Sak, 2004; Soh, 2017; Vally et al., 2019).

Recognizing the factors in the classroom that underlie writing and reading activities can help us to understand their impact on the development of creative thinking. However, there is a need for empirical evidence to contribute to our understanding of how creative thinking abilities develop during childhood and how they could be nurtured through the type of curriculum.

Cooperative learning and creative thinking.

Cooperative learning (CL) is described as a pedagogical practice that allows for positive social interaction, and that respects the diversity and individual needs and learning patterns of the students (Johnson & Johnson, 2002). Students work together in small, mixed-ability groups to maximise their learning through shared experience and common goals (Siegel, 2005). In CL children can act as learning promoters through dialogue (i.e. expressing opinions, points of view, offering hypotheses) and give input into the task in which they are involved. CL favors positive attitudes toward the task and interpersonal relations, and tends to improve communication skills (Johnson & Johnson, 2004). The implicit interactions in the structured work developed through CL can enhance motivation in low-performing children, promote reading and writing skills (Stevens & Slavin, 1995), and develop other skills related to reasoning and conceptualization (Gillies, 2011, 2014).

It has been proposed that CL, compared to other pedagogical approaches, positively influences academic achievement, socialization, motivation and personal development (Roseth, Johnson, & Johnson, 2008). In a meta-analysis of 24 studies carried out by Pai, Sears, and Maeda (2015), it was found that students' academic performance was significantly higher when the learning process was implemented in small cooperative groups, compared to those who worked competitively and individually. Moreover, Beghetto (2016) suggests that the social benefits derived from cooperative learning surpass those of other approaches, improving interpersonal relationships and peer-to-peer communication, facilitating peer-to-peer learning and motivating low-performing children. The most effective groups are those with four individuals or less, especially mixed-ability groups, due to the easier task distribution and greater interaction between its components Gillies (2014).

Johnson and Johnson (2009) suggested that five elements support CL: positive interdependence (PI), individual accountability (IA), face-to-face promotive interaction, social and interpersonal skills, and group processing. PI and IA are both relevant to group dynamics, such as group cohesion. They refer to the relationship between personal performance and group success. Students must feel the group's success as a result of each one's contribution, and the level of cooperative effort (Kyndt et al., 2013). Students must be responsible for their performance and learning, and thus the system prevents inequality in the process and reduces the probability of members who avoid making an effort. PI and IA can be promoted by goals, rewards (incentives to motivate students to complete tasks), resources (materials and information distributed to help complete tasks), roles (complementary functions of each member of the group), an identity (name or symbol of the group) and the environment (Brush, 1998). Control and assessments give important feedback for identifying individual needs and support their learning (Laal, Geranpaye, & Daemi, 2013). In CL, feedback between students is an important factor in the construction of knowledge. Promoting interaction in class aids in the objectives through assisting, sharing, encouraging and exchanging resources among one another. These face-to-face exchanges increase the level of social interaction, which helps to develop positive and cooperative attitudes (Zant & Kray, 2014). In addition, leadership attitudes, a climate of trust, communication and respect, and decision making are fundamental to social and interpersonal skills for effective CL. Finally, in assessing, processing or regular group self-evaluation, members discuss the level of implication and accountability of each, and assess which strategies are most effective in the process of learning (Kyndt et al., 2013).

The figure of the teacher plays an important role in cooperative group learning, acting to promote learning, monitor social interactions and coordinate the student groups. The teacher closely monitors the communication and dialogue among group members and provides the conditions for active participation and self-regulated behavior of the students (Eskay, Onu, Obiyo, & Obidoa, 2017; George, 2017; Gillies, 2014; Hunter, 1996). Hertz-Lazarowitz and Shachar (1990) observed that when teachers became involved in a cooperative learning system, they helped increase positive interactions in the classroom (agreeing on group objectives, respecting and supporting individual needs, and showing understanding and affection). The authors interpreted that this helped the students to establish a bond, making the learning environment a more spontaneous, varied, positive and creative place. This is consistent with the view of authors such as Shachar and Sharan (1994), who proposed that the success of the small student groups depends in part on the interaction of its members, and that this is more likely to occur when the teacher helps create more optimal conditions for positive interactions. The roles of the teacher and students are a fundamental aspect of CL, as well as the relationships established between them. The success of implementation of CL requires an understanding of its elements, and mastery in developing classroom management. In addition, students must understand their social and learning roles to achieve the expected objectives (Al-Yaseen, 2011; Gillies, 2003).

It is perhaps helpful to note that there is a similar approach to learning called Collaborative Learning—based on the work of psychologist Lev Vygotsky—which refers to a coordinated effort at problem solving that is typically described with adult students (whereas CL tends to be used with children). In their research on Collaborative Learning, Mercer and Littleton (2007) have shown that when teachers focus on language (group dialogue, or "thinking together") as a tool for exploration and reasoning, the quality of the students' work and problem-solving improves. Collaborative Learning also implies an emphasis on sociocultural perspective, in which the role of the teacher is to show students how to dialogue as a means of teaching how to think, and thus, how to learn, in the context of working together to solve problems (Mercer & Littleton, 2007).

The study of the development of creativity within the classroom has led researchers and educators to look for strategies that could favor creative thinking in the classroom (e.g. Moeller, Cutler, Fiedler, & Weier, 2013; Zhu, 2010). The predominance of research on the processes associated with creative thinking have suggested it can be improved with CL (Bolen & Torrance, 1978). In the view of some educators, CL encourages students to find novel solutions to the problems and helps to generate original ideas, using more varied reasoning strategies (Hattie, 2009). In fact, in a study based on analysis of the impact of CL and competitive learning, Qin, Johnson, and Johnson (1995) found that students in CL environments show higher levels of certain kinds of problem solving (e.g. linguistic strategies based on written and oral language) than do students involved in competitive learning. Studies that have analyzed the impact of the implementation of the CL suggest that the implementation of cooperative strategies can have a significantly positive effect on performance in tests of creative thinking or divergent thinking (e.g. CREA Test or TTCT) (Catarino, Vasco, Lopes, Silva, & Morais, 2019; Marashi & Khatami, 2017; Siew, Chin, & Sombuling, 2017; Sitorus & Surya, 2017). The diversity of thinking styles of the group promoted by cooperative learning can boost creative outcomes among students (Kim & Song, 2012). Finally, the cooperative environment helps individual students to be more socially sensitive, which can prevent tendencies towards restricted judgment, reduced awareness of complexity, or the inability to consider alternative and creative perspectives (Carnevale & Probst, 1998).

The above leads us to the hypothesis that a cooperative learning method is an appropriate context in which to study the development of creative thinking, and that it is likely to show more significant improvements in creative thinking when compared to a more traditional classroom approach.

Creative thinking and academic achievement

The relationship between creative thinking and academic achievement has been a controversial issue that has generated interest in educators and researchers in recent decades. Empirical work has thus far been inconclusive about the relation between these creative thinking and academics achievement (Gajda, 2016, Cline, Richards, & Abe, 1962; Freund & Holling, 2008; Naderi, Abdullah, Aizan, Jamaluddin, & Kumar, 2009; Olive, 1972; Yamamoto, 1967). Some investigation have reported positive associations (e.g. Escalante, 2005; Niaz, Nuñez, & Ruiz, 2000; Mourgues, Tan, Hein, Elliott, & Grigorenko, 2016; Wang, 2007; Zhang, Ren, & Deng, 2018), some have reported little to no correlation between them (Arya & Prasad, 2016; Edwards & Tyler, 1965); while others have even found a negative relationship between creative thinking and academic achievement (Anderson, White, & Stevens, 1969). Such varied results suggest that the relationship between creative thinking and academic achievement can depend on how the constructs are measured. In a recent meta-analysis, Gajda, Karwowski, and Beghetto (2017) examined the relationship between creativity and academic achievement and reported a slight positive correlation (r = .22) between them. The authors suggested that potential factors that could moderate the relationship, included the type of measurement used and the educational stage of student. They concluded that the relationship between creativity and academic achievement is stronger when: a) creative thinking is measured using quantitative tools (particularly verbal tests) as opposed to self-reports; b) students' academic achievement is measured by standardized tests rather than grade point average (GPA).

The present study

In the present study a structured program of reading and writing activities was developed for children of the fifth-grade of primary education that could be implemented within the curricular framework. For this, the reading and writing activities included in the program were based on the contents of the Language and Literature area of the official curricular proposal of the Spanish educational system. This, in addition to allowing the activities program to be applied within the classroom taking cooperative learning as an organizational and structural resource, also allow us to study their effects on the creative thinking potential of students compared to another similar group of students in which the same contents are used but with a traditional classroom methodology and does not receive the structured program of reading and writing activities.

We predicted that the cooperative learning group would show a significant improvement in their creative thinking potential between pre- and post-intervention scores on the CREA test. In contrast, we did not predict the same improvement in the control group. Additionally, taking into account the relationship that has been observed between creativity and academic performance, we also expect to find a positive correlation between improvements in creative thinking and academic performance (measured through GPAs)

Methods

Participants

Sixty students (30 female, 30 male) between 9 and 10 years old (*m*= 9.97; *sd*= .48) from a public school in the province of Almería, Spain, participated in the study. There is a large proportion of immigrant families among the school population (including from Romania, Morocco and other African countries), and the socio-economic environment is below average. Participants were assigned pseudo-randomly to two groups: the CL group (n = 30), which received the structured program of reading and writing activities based in the cooperative learning classroom; and the SL group (n = 30), which received the same content with traditional classroom programming based on the standard learning (SL) curriculum (see Table 1). Two different teachers worked with each group and independently designed their own scheduling based on official curriculum, without influencing each other.

The population consisted of Spanish and non-Spanish students. All children were enrolled from early childhood, and their level of acquisition of Spanish language proficiency has been progressively adapted along childhood. At the time of the study the acquisition of the Spanish language was at a level of linguistic competence within the prescribed parameters for their developmental stage according to the demands of the curriculum.

Table 1

Main characteristics of the classroom methodology used in CL (experimental) group and in SL (control) group[1].

Roles	Experimental group	Control Group
Teacher	Consensual learning. Proposes divergent solution activities. Facilitator of social relations. Stimulate communication. Proposes roles for the acquisition of commitments. Formative assessment.	Proposes what is going to be learned. Generally proposes activities of a only solution. Unilateral treatment of learning. Evaluation based on the rating.
Student*	Individual and group autonomy. Compliance with commitments. Communication attitude. Individual and grupal actitud. Consensus on what they want to learn. Self-assessment.	No group interdependence. Individual work. Any commitment is necessary. Individual attitude. Does not intervene in the planning of learning. Achievement of individual goals.
Contents	Learning based on instrumental use of language.	Theory about grammar, vocabulary and syntax.
Materials	Stories, news, poems, on-line resources, consumables.	Standardized textbook
Group work	Learning based on projects.	Didactic units (each fortnight).

[*] The design of the program for the development of creativity in the experimental group (activities, materials, contents and work groups) allows planning and search for solutions through consensus among the student themselves. The activities carried by the SL group come from a standardized textbook whose planning was pre-designed without priority being the interaction between students to reach a solution.

[1] ***Some clarification about the Spanish education system and approach to curriculum***. The Spanish Primary Education system structurally consists of six elementary courses, divided into three cycles of two years each. The contents are arranged into subject areas including Spanish language and literature, history, mathematics and science. Content learning is assessed through evaluation criteria organized throughout each cycle. The curriculum offers some methodological learning suggestions for students. Each school has the autonomy to use the most appropriate resources depending on the characteristics of its students, although the use of standard books is generalized, which serve as a reference to the teaching staff on programming and development of the teaching of each area based on the official curriculum. These textbooks offer teachers a standardized sequenced resource. From this predetermined plan, teachers can make some changes that can adapt to the reality or needs of their students. Teacher training is compulsory in the Spanish system but completed independently. Thus the methodological guidelines offered by the official curriculum are general and do not translate into concrete strategies, so the management and teaching practice can be determined according to each teacher's own style.

Measures

Creativity

In order to obtain the pre- and post-test measures of creative thinking in both groups (experimental and control), the CREA test was used, a test that allowed us to obtain a cognitive measure of creative thinking (Corbalán et al., 2003). The CREA test contains a picture and asks subjects to generate questions about the picture. Responses are given in writing. There are three forms, each with a different picture (A, B and C), but the same task and instructions. A picture is presented to the subjects and they have to elaborate the largest possible number of questions during a maximum time of 4 min. All the questions are valid except repeated questions, clearly decontextualized questions and "repertory" questions without justification (e.g. What?, when?, how?). The test provides a single score which is based on the total number of appropriate responses (one point for each appropriate response), although an extra point could be given for those questions that refer to more than one cognitive scheme (e.g., “Is the handle used to charge the phone, or as a prize machine?”). The test can be administered individually or collectively, and each form (pictures A, B and C) is directed to different age groups. Thus, forms A and C can be used with children between 10 and 16 years. The authors of the CREA test also indicate that A and C forms are suitable for the third cycle of primary education (fifth and sixth grades), which was the level of the children participating in this study. Before the test begins, there are several practice trials in which the experimenter ensures good comprehension of the instructions, (e.g., emphasizing the difference between a question and another type of elaboration). The CREA test has showed a strong reliability, convergent validity with Guilford’s divergent thinking tasks, and discriminant validity with academic aptitude measures in children and adults (Corbalán et al., 2003).

Academic achievement: grade point average (GPA)

Grade Point Average (GPA) was used for all subjects from the trimesters during the academic year. Academic achievement was periodically assessed by internal school exams in the following subjects: Language and Literature, Mathematics, Arts, Science, Physical Education and English. The evaluations were based on official curriculum evaluation criteria. Scores were given in 5 levels depending on academic performance: insufficient (1), sufficient (2), good (3), notable (4), excellent (5).

Procedure

A quasi-experimental pre-test/post-test design with control group was used. At the beginning of the second trimester of the school year (February), the form A of the CREA test was administered to all students in the CL group simultaneously, to obtain the pre-test creative thinking scores. Then, a structured program of activities of reading and writing was administered in classroom (during the the classes of the subject of Spanish language and literature) for a period of 7 weeks, which included 12 sessions of 120 min each.

The program included a total of 10 different activities which were based on the basic contents of the official curriculum, therefore, they included learning of different literary genres and subgenres (Narrative-telling and fables, Theater, Poetry, Didactics of biography and poetry), as well as the recognition of structures and specific content of each literary genre. Each session was preceded by the reading of a fragment of 'The Little Prince' (Antoine de Saint-Exupéry). This reading activity could be carried out in class, at the beginning of the session, or at home. All activities of the program were carried out in heterogeneous cooperative groups of 3 or 4 students. Previously, the students had been classified into three categories: students capable of helping others, students with learning difficulties, and the remaining students; then, students were assigned to groups with at least one student from each category per group. Each student chose a role within the group (coordinator, secretary, speaker and controller), implying the acceptance of a series of functions and work commitments within the group. For example, the controller was in charge of keeping group order (materials, time of each activity, noise); the secretary helped to keep the group's commitments (homework, team work and decision-making); the speaker represented the group (talking to the teacher, establishing communication with other teams); and the coordinator supervised the attitudes of the rest of the team (maintain interactions, encouraging team work). The role of the teacher was to guide (give examples, remind students of reading situations), to advise (grammatical aspects or syntactic structure) and to encourage students to take risks without fear of making mistakes. The specific activities included in the 12 sessions of the program are described below.

Sessions 1 and 2: Short story with 5 key elements. These sessions began with the collective reading of part of the play " The Little Prince ", which was discussed among the students in a group. Grammatical and semantic aspects were analyzed, the content and structure (characters, places, etc), and the relationship between different elements of what was read (emotional links between the characters). Once these aspects were analyzed, students had to write a short story based on 5 chosen elements from the part of the story they had read. For this, the students had to agree on those aspects that would be used for their story, as well as characters, scenarios and the role of each character within the story. For the writing of the story they had to respect formal structures as an introduction, development and outcome of events.

Session 3: Reading poems. In this session students have to analyze different poems selected by the teacher. After this activity was carried out, teachers proposed that the students wrote their own selection of poems (search at home, in the library, internet, etc.)

so that later they could share them with the rest of the class. The dynamic of cooperative learning for the development of this activity was the technique "1-2-4" (Pujolàs & Lago, 2002), in which the individual work should be shared in pairs. The purpose was to analyze the most important aspects of the poems of each component, to then be shared with the base group (4 individual). All poems were analyzed around the feelings and emotions of the characters of the reading ”The Little Prince ”.

Session 4: Futureme. Through an application called ”Futureme” (Labs, 2002-2018) students were encouraged to write an e-mail to themselves, from the present to their future selves. This activity took place at home, and was later shared with the rest of the class. Once students shared with classmates and received suggestions for the grammar and syntax, students sent their emails from home. With this activity the student was encouraged to reflect on their own ”I”. In addition to using certain verb tenses, the student makes an imaginary and introspective journey towards their own "I", projecting an image of themselves based on their aspirations, desires and dreams.

Session 5: Custom fables. Each of the groups were asked to elaborate a narrative by choosing a specific animal that would represent each member of the group. Then they had to individually write their stories without revealing whom was represented by each animal. Finally the fables were read and the members of the group had to guess which animal represented each member of the group.

Session 6: Inspiring start. In this activity, students individually had to invent an alternative beginning to a given story. The teacher provided an incomplete fragment of a newspaper story, in which the title and beginning of the news was missing. Each student had to write a beginning for the incomplete fragment, and then share with groupmates. After analyzing the most interesting aspects of the individual proposals of the four individuals in the base group, the students jointly redesigned a beginning for the news story.

Session 7: Meeting of two comic characters. For this activity the students were asked to invent a story whose protagonists were characters from fiction movies or comics they knew, for example Superman or Batman. Each group member selected a fictional character and gave a brief description of their physical and personal characteristics. Later, the base group agreed on and established the relationships between characters that would serve as the basis for inventing a story that each student would have to write individually.

Sessions 8 and 9: Autobiography. In these sessions the students had to learn to write their own biographies. To analyze the structure of a biography, the cooperative technique of "the revolving conceptual map" was used. On a table was a blank page with the word ”Biography ” in the center, the sheet is rotated by the group, and the students in turn, wrote the most important aspects of the biography (date and place of birth, family history, likes, etc.), sorting them according to their relevance around the center of the page. After having completed the rotating conceptual map with the base group, the students wrote their autobiography, taking into account the items written on the sheet, and later sharing it with the base group. Later, each member of the base-group had to explain orally to the rest of the students the aspects that they considered most relevant in the lives of their classmates.

Session 10: "If I were …" In this session the students, individually, were invited to propose a social problem from their own personal environment (for example, poverty). From this proposal students had to find a solution to the problem by imagining that they were a character, either fictitious (could be invented by themselves or be a character from another story) or real. The final products were shared with the rest of the class and exhibited in a visible place in the classroom.

Session 11. ''*What would happen if…”.* In this session the students were asked to imagine an unusual situation (for example, that it was raining flowers). The base group members agreed on an unusual situation and later, individually, they would write a story about the situation and its consequences.

Session 12. History in bags. Through this task the students had to write a story in a collaboration with each other. For this they used three small bags, each of which was had its own color and name: characters, arguments or scenarios. There students brainstormed ideas that could be included each bag. Each child wrote a character, a scenario and an argument and then placed it in the corresponding bag. Afterwards, the base group removed one paper from each bag and collaboratively wrote a story from their selected elements.

In the control group the teacher used a standardized textbook as the main resource for the programming and development of the activities in the class of Spanish language and literature (Vicent Vives Ed.). The basic program of this textbook consisted of 15 teaching units which must be taught during the school year. Each teaching unit was evaluated every two weeks through an exam based on the contents (basic learning) of each unit. Table 2 shows some examples of the specific activities carried out by the control group in the subject of Spanish language and literature.

After the administration of the program in the CL group, CREA test form C was administered to obtain creative thinking post-test scores. In the SL group, the pre-test creative thinking scores (obtained through CREA test form A) were obtained at the end of the first trimester of the school year (December). As with the CL group, 7 weeks after the pre-test, CREA test form C was given to the SL group to obtain the creative thinking post-test scores. Thus the time elapsed between pre-test and post-test (7 weeks) was identical for both experimental and control groups.

Statistical analysis

The data were analysed using the statistical program IBM SPSS Statistics (version 23). First we performed a Kolmogorov-Smirnov test (with Lilliefors correction) to determine whether the study variables showed a normal distribution. For those variables considered normal, parametric contrasts were performed in order to observe differences between the CL and SL groups (student's T-test for two independent samples). For those variables that did not meet the normality assumption, one of the following nonparametric tests were applied: a Mann-Whitney U (for independent samples), or a Wilcoxon rank test (for related samples).

Ethics

The management team, teachers, students and families were informed about the objectives and procedures of the research, but the students did not know about the application of the specific programs. With the exception of the evaluation of creativity, which required the consent of families, the participation of students in the programs was compulsory, since these interventions were carried during school time and following the guidelines of the official curriculum (teachers are free to design their own methodological programs and specific content structuring). Therefore, each teacher independently designed their own programming (activities, materials and methodology) following the protocol and ethical standards of the school. To protect students' identity, they were numerically coded. Finally, the participants were informed about the results obtained in this study.

Table 2.

Examples of specific activities carried out by the control (SL) group in the subject of Spanish language and literature during the 7 weeks between the pre- and post-test assessment (Vicent Vives Ed.).

Section	**Contents**	**Activity**
Introduciton	Healthy lifestyle	Reading activity (group or individual).
What do you read?	Childhood obesity increases	Reading and debate activity
Reading comprehension	Mediterranean diet	a. Reading the text (group or individual). b. Copy in your notebook the next sentences, and indicate if they are true or false (E.g.Mediterranean diet is typical of Australia. c. What does ‘’physical activity promotion” means? Students must write the question in their notebook and choose answer from three given by textbook.

		d. Observe the statistic graphics and answer the next questions. (E.g. In the world, Who suffer more obesity, the girls or boys?)
How do it?	Learn to summarize a text.	a. Read and copy ''SUMMARY'' definition in your textbook. b. Read and copy the 6 steps for summarising a text. c. Make in your notebook a summary of the text ''Increase in childhood obesity''.
Grammar	Determinants articles	a. Read the meaning of the determinants articles. b. Copy in your textbook two classification tables of determinants articles. c. Copy in your textbook the next sentences and highlight the determinants articles.

Results

Comparisons between CL and SL groups

We first tested whether the CL and SL groups were equivalent in demographic characteristics (distribution of sex, age and nationality), initial level of knowledge in the subject of Spanish Language, and pre-test creativity scores (see Table 3).

As shown in Table 3, children in the SL group were somewhat younger than the children in the CL group. This was due to the fact that the pre-test evaluation was not carried out in the same trimester of the school year for each of the two groups. While in the CL group the pre- and post-test measures were taken during the second trimester of the school year (February-March), in the SL group measures were taken during the first trimester of the school year (November-December). Despite the difference in dates of the preand post-test measures between groups, both groups were in the same school year (5th grade of primary education) at the time of the pre- and post-test, and the time between the pre- and post-test was equivalent (7 weeks) in both groups. In addition, the CL group had a higher proportion of students of non-Spanish nationalities than students of Spanish, whereas the SL group showed the reverse. Nevertheless, as we did not observe any differences concerning either the initial level of knowledge of the Spanish Language (reading and oral comprehension, and written expression) or the creativity pre-test scores, we considered the groups to be sufficiently equivalent at pre-test for the purposes of this study.

Table 3

Demographic characteristics, initial level of knowledge in the subject of Spanish Language, and pre-test creativity scores obtained by control and experimental groups.

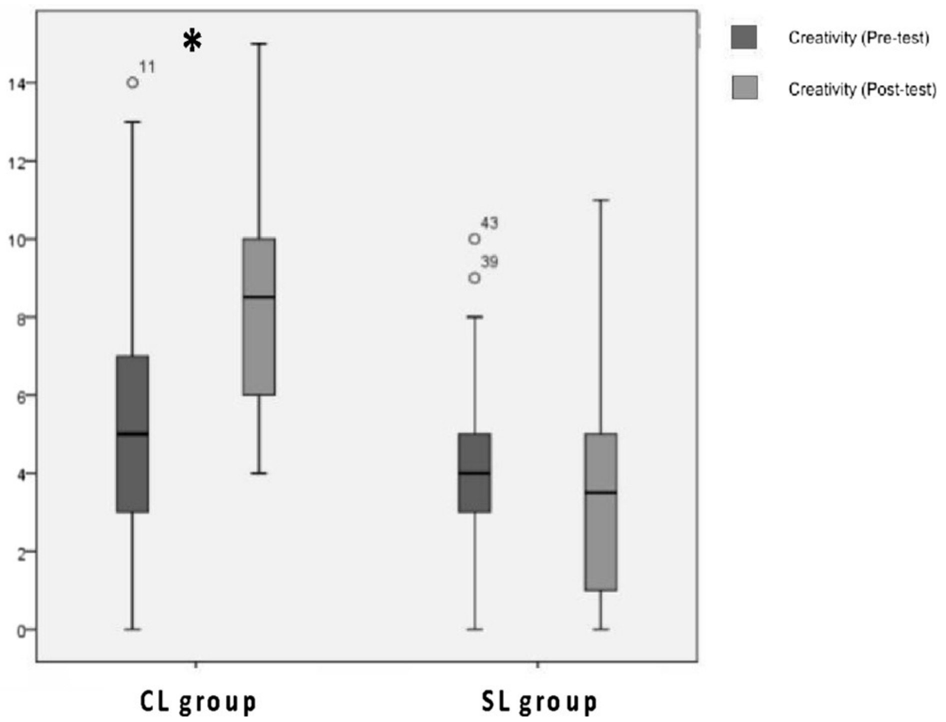
	Control group (n = 30)	**Experimental group (n = 30)**	**Statistics**	***p***
Age (Mean; *DT*)	9.80 (.48)	10.13 (.43)	U=317.0	.008
Sex (n) Male	15	15	χ^2=.000	1.0
Female	15	15		
Nationality(n)				
Spanish	21	9	χ^2=11.28	.001
Non-Spanish	9	21		
Moroccan	0	4		
Romanian	5	15		
Other	4	2		
Spanish Language*	2.87 (1.40)	2.67 (1.29)	*U = 415.0*	.596

(max. score = 5)				
Creativity pretest score	4.03 (2.4)	5.47 (3.31)	*U* = 331.5	.077

* Spanish language skill was assessed by an official exam of linguistic competence at the beginning of the academic year in the course Spanish Language and Literature. All students take this exam at the beginning of each year, which individually assesses the level of proficiency in each subject.

Figure 1

Pre- and post-test differences in creative thinking scores



Effect of the intervention

Improvement in creativity

With the scores obtained in the CREA test, Wilcoxon rank tests indicated that the CL group significantly improved from pre- to post-test (Z = -4.57, p =.000), and the effect size was robust (r = 0.83), which was not the case for the SL group (see Fig. 1).

We observed that 90 % of the children in the CL group showed improved CREA test scores after the intervention, in contrast with only 43 % of the children in the SL group. In addition, in both groups, an improvement score on the CREA Test was calculated for each child (subtracting the pre-test score from the post-test score). The improvements in

CREA test scores showed no significant differences in gender or nationality; and no significant correlation with age or with Spanish Language test scores.

Academic achievement

We observed a moderate correlation between creativity pre-test scores and GPA in the first trimester of the school year (r = .27, p = .03). Wilcoxon rank groups showed significant differences between pre- and post-test GPA for both groups. Thus, the intervention program did not seem to have a significant impact on the available measure of academic achievement.

Discussion

In this study we examined the effects of a structured program of reading and writing activities based on the contents of Language and Literature from the official Spanish educational curriculum, which was applied within the classroom taking cooperative learning as an organizational and structural resource. Our results showed that improvement on the CREA Test was significantly greater in CL group as compared with the SL group, suggesting that the intervention had an impact on creative thinking.

The present findings are consistent with previous research designed specifically for school-age children, in support of the hypothesis that creative thinking is not a static element, but a fluid construct that can be stimulated through specific training. Recent studies have reported significant improvement in creative thinking after a targeted training in children from 10 to 14 years old (Doron, 2017), and improvements in children from 7 to 12 years old, on the components of creativity such as fluency, originality and elaboration (Gu et al., 2019).

The activities used in the present study placed emphasis on reading and writing activities, which encouraged students to produce original literary texts based on specific writing resources. Besides being a program designed to enhance creative thinking, it was based on development of Linguistic Competence from the curriculum of the Third Cycle of Primary Education of Spanish Language and Literature. Through this program we aimed to promote peer interaction, and a multiplicity of experiences (text analysis, shared reading and production of literary texts), with cooperative learning as an organizational structure. The students' interactions were respectful of the abilities, needs and learning styles of each individual, and of the figure of the teacher as a facilitator of learning. In this sense it is to important note that the teacher’s role in the CL (experimental) group may have been critical in promoting these interactions among students. In previous studies it has been observed that teachers who change their instructional style to cooperative learning tend to use language in more spontaneous, varied, and creative ways, and communicate more positive affective messages to their students (Gillies, 2014). On the contrary, in a traditional teaching structure such as that used with the SL (control) group, the teacher's language is usually more rigid and less friendly. It is the teacher who directs the learning while the students are more passive. In our study, the teacher of the SL (control group) reported that no special strategy or activity was carried out (e.g. attention to student diversity). However, in the experimental (CL) group, the teacher designed the activities with the purpose of promoting imagination and freedom in the final product (narrative, stories, poems, letters, emails, comics, etc.), fostering interaction through cooperative learning, and the possibility to influence this in student creative thinking. Our findings are congruent with previous studies which reported that teachers, when engaging in cooperative learning, generate more positive patterns of dialogue and emotional communication with students, and favor spontaneity, variety and creativity (Gillies, 2014).

The students were encouraged to participate actively, and to analyze, manipulate and project the different literary resources that led them to the generation of their own ideas. These characteristics are similar to other training programs carried out in previous empirical research that show that when children are encouraged to share their knowledge and skills acquired based on their own interests, they tend to participate more effectively, even improving their creativity writing ability (Doron, 2017).

Our findings are in line with other studies which reported lower correlations between creative thinking and academic achievement when the latter was measured using grade point averages (GPAs) instead of externally constructed, standardized tests of academic subject matter knowledge. In a recent meta-analysis Gajda et al. (2017) suggested that when subjective measures are used to track academic success, it becomes possible for teachers to prioritize student abilities other than the generation of original ideas, and other such skills in creative thinking. Even the use of GPA as an evaluation of students' work can send a message that originality is not necessary or valued. In this way, students could tend to learn that the effort to be creative is not worth the relative risk. In fact, there is evidence that some teachers hold negative perceptions towards student behaviors that are associated with creativity (Gajda et al., 2017). This could potentially explain why in the present study, in which academic achievement was measured via GPA, although students in the CL group improved in their creative thinking scores, they did not show a corresponding improvement in grades. GPA may not be the best suited to measure how an improvement in creative thinking could possibly impact academic achievement, and we underscore that this point should be taken into consideration in future investigations.

The significance of the present study lies in the result that it is possible to improve creative thinking through a particular curricular framework.Our study suggest that the school environment has an extraordinary potential to develop creative thinking of students through curricular subjects and specific methodological strategies. The school offers a rich environment for interactive experiences and expressive possibilities, which may be optimal for the promotion of creative thinking (Beghetto & Kaufman, 2014).

Although the training program was fairly intensive and had a significant effect on divergent thinking, differences on academic performance after intervention were not found. Thus, we cannot draw definitive conclusions about the effectiveness of the training on both creative thinking and academic achievement for two reasons: a) the short-term nature of the training; and b) the sample size (N = 60). A larger sample and a longer-term training would allow us to observe more fully the effectiveness of the training on creative thinking and academic achievement, as well as the development and differences in both groups. Another limitation that could have particularly influenced the interpretation of academic performance is the type of evaluation. Although both the design of the activities and the evaluation of academic performance were within the curricular parameters, it is possible that acquired skills related to cooperation and creative thinking that are reflected in children's final products are not transcendent in current curriculum assessment models. This means that there could be biases that prevent an accurate evaluation of the skills acquired by the students throughout the training program. In future studies, we suggest evaluative aspects be introduced as well as specific learning rubrics, external and / or standardized tests instead of GPA.

Finally, the CREA Test has a predictive and concurrent validity with other tests such as the Guilford Test and the traditional components of divergent thinking are valued (fluency, elaboration, originality and flexibility), but the evaluation of creative thinking is focused on a very specific domain (verbal measure). That means that the use of other measures that involve visual or figural tasks (e.g. Torrance Tests of Creative Thinking -TTCT-), would help to further analysis of impact of the intervention for the development of creative thinking across different domains. This possibility could be considered in future research.

As described above, a large number of non-Spanish/bilingual children participated in the present study (see Table 2). Although we did not find statistically significant differences between bilingual (n = 30) and non-bilingual children (n = 30) with the pre- and post- measures of creative thinking, it is important to note that different factors related to the the condition bilingual/non-bilingual (e.g. frequency of use of the mother tongue in daily life of students, different degree of bilingualism), which have not been controlled in the present study, could have had a moderating effect on our results. In this sense, previous studies have suggested that bilingualism may contribute to the development of creativity in problem solving in children (v.g. Leikin, 2012; Leikin & Tovli, 2014). For example, Leikin and Tovli (2014) findings suggested that bilingualism could improve the flexibility and originality of thinking in children, especially in tasks of mathematical creativity. In addition, these authors observed that bilingual children who received a solid form of bilingual education showed higher creativity in problem solving than children who received a weak form of bilingual education.

Nevertheless, this study helps to open a new horizon for future studies in which we investigate in more depth the cognitive processes involved in creative thinking.

In conclusion, our results suggest that a creative training program developed within the public school curriculum can enhance creative thinking in children. It is interesting to consider the social and educational importance of creativity and its development in the school environment. We propose that future research focus on improving our understanding of the nature of creative thinking, and how it can be fostered in education through specific methodological programs contextualized within the official curriculum.

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E2

Development of executive functions in late childhood and the mediating role of Cooperative Learning: a longitudinal study.

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Cognitive Development Journal (En revisión)

Abstract

We examine the developmental changes in Executive functions (EFs) throughout late childhood and how the contextual factor of classroom methodology mediates such changes. Using data collected from fifty-three pupils at two time points (between the 5th and 6th grades of Primary School) we observed the longitudinal development of cool (Working Memory (WM), Cognitive Flexibility, Inhibitory Control, and Planning) and hot-EFs (Emotional Intelligence-EI-). The participants were selected from two schools with different methodological approaches (Cooperative and Individualistic learning) to examine the mediating role of classroom methodologies in developmental changes in EFs. The results revealed age-related improvements in performance on WM, cognitive flexibility, and planning tasks. Moreover, Cooperative Learning (CL) significantly affected performance on WM and self-control tasks. Our findings highlight the importance of studying the development of EFs at the end of the Primary School stage, since natural development involves numerous contextual factors that deserve attention, particularly for improving methodological proposals and learning processes.

Keywords: Executive functions, development, cooperative learning, classroom methodology.

Abbreviations: Cooperative learning (CL); Individualistic learning (IL); Executive Functions (EFs); Working Memory (WM); Emotional Intelligence (EI).

Introduction

Executive functions (EFs) are generally considered to be processes that allow thoughts and actions to be directed toward a goal through the planning, monitoring, and controlling of behaviors and emotions (Diamond, 2013). These cognitive processes are essential for effective, creative, and socially adaptative behavior (Bryck & Fisher, 2012; Lezak, 1982). EFs are involved in cognitive and social abilities such as language, problem solving, abstract reasoning, and regulation of emotions, and they could show a developmental association throughout childhood (Boerma & Blom, 2020; Kotsopoulos & Lee, 2012; Ropovik, 2014; Spruijt et al., 2018).

The development of EFs during childhood implies the development of a set of cognitive abilities that must allow the child to: a) manage information; b) self-regulate and adopt reflexive and non-impulsive decision-making behavior; and c) adapt their behavior to the demands of the current context. Consequently, EFs contribute towards the acquisition of participative, active, and reflective attitudes necessary in the teaching-learning processes (Marcovitch, et al., 2008). The development of EFs begins at a very early age and extends throughout the lifespan, with middle and late childhood being a critical period due to the changes associated with the development of neural networks involving the prefrontal cortex (PFC) during this stage (Anderson, 2002; Zelazo & Carlson, 2012).

Due to the relevance of EFs for children's cognitive and social functioning, it is important to understand how EFs develop and identify those factors that could play a mediating role in individual development during late childhood (Lensing & Elsner, 2018). In this sense, previous investigations have suggested that Cooperative learning -CL- (as contextual factor) play an important role on EFs as well as cognitive and socio-emotional development (Staiano et al., 2012). The kind of social interaction promoted by cooperative structures in classroom might have a significative impact on learning abilities and/or cognitive and socio-emotional processes compared to individualistic or competitive methodologies (Beghetto, 2016; Fawcett & Garton, 2005; Pai et al., 2104; Sabol et al., 2013; Segundo et al., 2020).

Therefore, the present study aimed to observe the cognitive and socio-emotional changes in late childhood over two years. Moreover, we examined the mediating role of two different classroom methodologies (Cooperative and individualistic learning) in these developmental changes in EFs.

Executive functions: cool and hot.

Traditionally, EFs have been understood as domain-general functional constructs, although some researchers have suggested a distinction between the following two components: 1) *Cool-EFs*: cognitive processes which support goal-directed behavior under relatively abstract, decontextualized, non-emotional conditions; and 2) *Hot-EFs*: related to affective aspects associated with situations that involve emotional regulation and motivation (Zelazo & Carlson, 2012; Zelazo, et al., 2005).

Regarding *Cool-EFs*, three key cognitive components have been identified: WM, Inhibition, and cognitive flexibility (Diamond, 2013; Garon et al., 2008; Lehto et al., 2003; Miyake & Friedman, 2012), which could be the base for more complex executive processes such as reasoning, problem solving, and planning (Diamond, 2013). Although there are some differences in their developmental trajectories (Fernández-García, et al., 2021), these three components appear to operate in an interactive manner (Best & Miller, 2010).

WM is responsible for actively operating and mentally maintaining information (Diamond, 2013). Even though WM is a limited capacity system whereby information is temporarily stored, it allows this information to be managed and transformed into thoughts and actions, and thereby supports essential processes such as written or spoken language, or mathematical reasoning (Titz & Karbach, 2014). An important feature of WM is its capacity to continuously replace old information with new and relevant data, which is widely known as the updating process that allows for establishing connections between various ideas, and the consideration of various response options (Carriedo et al., 2016). Baddeley's (2003) multi-component model is one of the most widely accepted cognitive frameworks of WM among researchers in the study of executive functions. Baddeley's model includes a central coordinating executive system and at least two modality-specific components: the phonological loop, which maintains speech-based (phonological) information; and the visuospatial sketchpad that supports nonverbal, visual, and spatial data. The central executive system is assumed to maintain and encode information when the phonological loop and visuospatial sketchpad are saturated, that is, it is a control system capable of facing the demands of the task that would otherwise limit the processing space and cognitive resources of the subsidiary systems (Gathercole et al., 2004).

The term inhibition refers to the control procedure whereby the individual suppresses contextually inappropriate responses to generate mental and/or behavioral responses that are adapted to environmental demands. Inhibitory control comprises at least two cognitive components: a) inhibition of automatic or prepotent responses, and b) the ability to resist interference from distractors in a conflict task (Friedman & Miyake, 2004). The adequate development of inhibitory control is linked to normal performance on other neuropsychological abilities such as working memory, spoken language, and self-regulation (Barkley, 1997).

Cognitive flexibility concerns the ability to efficiently switch between tasks, operations, or mental sets (Miyake et al., 2000). Cognitive flexibility allows children to shift attention, efficiently focus on changing environmental demands, and adapt their behavior to new situations. This component of EFs has been linked to problem solving efficiency, writing skills, and arithmetic (Bull & Scerif, 2001; Hooper et al., 2002).

From the three core EFs, other higher-order processes emerge such as planning, which is defined as the ability to mentally organize behaviors to generate and structure sequences of responses. Thus, planning enables children to coordinate sequences of actions in time and space when a goal requires the achievement of a series of intermediate steps. Normal development of this planning ability allows for implementing flexible and adaptive behaviors necessary for cognitive skills such as problem solving or reasoning (Ward & Allport, 1997).

There is generally a degree of consensus among researchers that hot-EFs are those processes of control that are required in situations with a significant motivational and emotional component, or those that elicit a conflict between immediate reward and long-term goals (Zelazo & Carlson, 2012). There is, however, rather less agreement regarding the composition of hot-EFs (Fernández-García et al., 2021). Some authors consider that Emotional Intelligence (EI) and related aspect of social cognition (e.g. theory of mind, emotional regulation, empathy, affective decision making, judgment or social skills) should all be included under the category of hot-EFs (De Luca & Leventer, 2008; Fernández-García et al., 2021; Happaney et al., 2004; Keifer & Tranel, 2013; Kerr et al., 2004).

Studies conducted during middle and late childhood have found a link between EI and performance on tasks typically related to hot-EFs (e.g., Iowa Gambling task; Li et al., 2017). Moreover, some researchers have suggested that EI (e.g. sociability, social awareness or capacity to perform interpersonal relationships) could predict performance on hot-EF tasks in adults (e.g. Telle et al., 2011). EI has traditionally been considered a set of emotional and socially adaptive skills. According to Mayer and Salovey (1997) EI includes four basic processes: a) the accurate perception and expression of emotions, b) the use of emotion to facilitate thinking through the ability to access and/or generate feelings, c) the understanding and knowledge of emotions, and d) the management and regulation of emotions.

In Salovey and Mayer (1990) model they consider empathy central to social understanding and interactions given the role on appraisal and expression of emotion applied to others. Empathy is the ability to perceive, understand and/or share feelings with others — as well as thoughts and emotions — are all processes associated with empathy. Empathy is related to interpersonal and prosocial behavior, as well as lower levels of aggression and fewer bullying behaviors in Primary school (Abramson et al., 2020). Empathy includes two dimensions: 1) the cognitive dimension, which refers to the ability to recognize and understand the emotions of others. Cognitive empathy can be indicated by the capacity of a perceiver to understand the subjective states of others; and 2) the affective dimension, which refers to the ability to share and experience an emotion observed in others, even when the event does not directly affect the perceiver (Jolliffe & Farrington, 2006).

Development of EFs

The processes attributed to EFs begin to develop at an early age and undergo rapid and significant changes during the preschool period, with development extending into late childhood after adolescence (Carlson, 2005). The gradual maturation of EFs co-occur in parallel with the prolonged development and integrity of the pre-frontal cortex (PFC), a brain region related to skills such as planning, organization, and complex decision making, along with abstract thought and emotional regulation (Daniels et al., 2006). Developmental studies have suggested changes in EFs across the lifespan, specifically, in middle and late childhood, although conclusions on this issue are mixed and unclear. Alloway and Alloway (2013) found significant changes between the ages of

5 to 12 years in performance on manipulation and maintenance of information in WM tests (both verbal and visuo-spatial content). In a similar vein, Siegel et al. (1989) compared the capacity to maintain and update information in children of three different age groups (7-8, 9-10 and 11-13 years), and found significant developmental changes in both verbal and non-verbal WM tasks. Moreover, significant improvements in inhibitory control during middle and late childhood have been found, although empirical studies have produced mixed outcomes. Mullane et al. (2014) found evidence for developmental changes in executive control in children aged 6.5 to 12.5 years. Their findings indicate an improvement in the capacity to resolve interference caused by simultaneously activating correct and incorrect responses during middle and late childhood. These findings are in accord with those of other studies using flanker tasks, which suggest that executive control (i.e., interference control) improves during this period (Enns & Akhtar, 1989; Ridderinkhof et al., 1997; Simonds et al., 2007). However, Rueda et al. (2004) in a cross-sectional experiment, compared different age groups and found no changes in executive control beyond the age of 8 years. In a similar vein, Ridderinkhof et al. (1997) found improvements from 5 to 10 years, but almost no differences between the age of 10 years and adulthood. These findings therefore suggest that conflict resolution introduced by incongruent flankers is stable after this age. Regarding cognitive flexibility (switching between rules), it is a well-established finding that this improves during childhood (Buttelmann & Karbach, 2017; Jacques & Zelazo, 2001). Davidson et al. (2006) found significant improvements in performance on switching tasks between the ages of 4 to 13 years, although the participants did not reach adult levels at this latter age. Similarly, Dick (2014) explored cognitive flexibility in 6- to 10-year-old children and adults and found improvements in switching-task performance with the passage of time. Unlike Davidson's study, Dick's findings suggest that children reach adult levels of performance at 10 years of age. With regard to the development of planning, some studies have

reported age-related changes in late childhood. Bishop et al. (2001) found substantial variations in performance on the Tower of Hanoi task in participants between 7 to 26 years old. The authors observed a rapid increase in early childhood (up to 12 years old), which then slowly declined (13- to 15-years-old), before reaching a stable level in young adulthood. Similarly, Matute et al. (2008) revealed a notable increase in performance on the Tower of Hanoi task from the early years until the age of 11. Improvements in this higher-order skill have traditionally been linked to the development of the core EFs (WM, cognitive flexibility, and inhibitory control; Diamond, 2013).

Emotional development occurs during sensitive periods such as transition between middle childhood and adolescence (Gee, 2016). However, this sensitive period is determined by environmental stimuli that may ultimately influence an individual's behavior in both positive and negative ways across the lifespan (Masten & Cicchetti, 2010). Dramatic changes in emotional competence have been observed throughout the first year of life. The first evidence for the development of emotional skills (i.e., perception and recognition of emotions) can be observed at 3-5 months (Heck et al., 2018). After this, a cascading series of events occurs (e.g., language development) which lead to the appearance of more complex emotional abilities such as understanding or regulation of emotions, along with social skills (Rosenblum et al., 2009). Subsequently, in this developmental process, children learn to express and label their emotions and feelings, and use these as a guide to regulate their own behavior (Zeidner et al., 2003). A study conducted by Kolb et al. (1992) has indicated that there are some critical periods in this developmental process. The results of their study showed a significant improvement in emotion recognition between 6 and 8 years, with few changes observed up until the age of 14 years. The understanding and management of emotion regulation strategies could depend upon the individual development of skills such as language (Cole et al., 2009). In fact, linguistic development is essential for the acquisition of an emotional competence that allows the child to both express their emotions correctly and generate appropriate communication during social interactions (Zeidner et al., 2003). Eisenberg et al. (1987), in a longitudinal study, found that processes related to language such as reasoning (moral reasoning) are associated with empathy. Moreover, these authors found an age-related sequence of development for prosocial moral reasoning between the ages of 9 to 12 years. The authors found that hedonistic reasoning decreased with age whilst they observed an increase in more sophisticated reasoning, which includes positive affect, direct-reciprocity, and approval-oriented reasoning. In addition, they found an increase in pragmatic reasoning, particularly in this age range.

In summary, emotional development throughout childhood is subject to changes associated with other developmental aspects (e.g., language skills), which could promote prosocial behaviors.

EF development and the school context: Cooperative Learning vs individualistic learning

School is an environmental factor involved in the development of EF, since it offers an exclusive context where children develop their cognitive, social, and emotional activity (Bohlmann & Weinstein, 2013; Poulou, 2014). There is evidence that methodological resources with a social component have an impact on the child's cognitive and socio-emotional development (Staiano et al., 2012). In this sense, cooperative structures could be an important predictor for learning skills (Sabol et al., 2013) and executive performance (cognitive and socio-emotional) from early years (Bodrova et al., 2006; Hamre et al., 2013; Rimm-Kaufman et al., 2009; Staiano et al., 2012; Weiland et al., 2013). Moreover, some authors have suggested that CL is more beneficial for the cognitive processes in students (e.g., problem-solving, creative thinking), and their academic achievements or social skills when compared with learning that is based on individual and competitive work (Beghetto, 2016; Fawcett & Garton, 2005; Pai et al., 2105; Segundo et al., 2020). For instance, a study by Fawcett and Garton (2005) found that children showed significantly better performance on a problem-solving task when taking part in a collaborative interaction than those children who worked individually. Moreover, some studies have also shown evidence of how WM performance can be influenced by social interactions in school throughout childhood (de Wilde et al., 2015; Vandenbroucke et al., 2018).

CL is a pedagogical practice that favors positive social interaction and is based on the notion of respect for diversity and individual needs, as well as the learning styles of the students (Johnson & Johnson, 2009). In CL, students work together in mixed-ability groups of four individuals or less, which facilitates task distribution and greater interaction between students (Gillies, 2014). By promoting interactions, children establish reciprocal dialogue and learn to share new experiences and realities, encouraging each other and exchanging resources among themselves (Mercer, 1994). CL provides a balance between individual performance and group success, and a context in which individual accountability is clearly established, while the goals are achieved by the collaborative efforts of all group members. Through face-to-face interaction, CL promotes social skills (e.g., respecting norms and roles), children can use language distinctively and creatively, and they can construct new ways of thinking and learning. CL supports a group-based dynamic which involves self-evaluation of the involvement and accountability of each member, and the analysis of the most effective strategies within the learning-process (Kyndt et al., 2013).

Despite the empirical evidence on the importance of learning strategies for EF development, more studies are needed to clarify the mediating role of teaching methodology (particularly CL) in EF development throughout the school stages.

The present study

The purpose of this study was to longitudinally examine the development of various EF components (*cool* and *hot*) in children throughout the 5th and 6th grade of Primary School (9 to 12 years), and to determine if the classroom methodology (Cooperative and individualistic learning) could mediate individual developmental differences. Therefore, we expected to find: (1) a significant increase throughout late childhood in *cool* and *hot-EFs*, and (2) that children involved in Cooperative Learning (CL) as a classroom methodology significantly improve compared with those who engage in individualistic learning (IL) in terms of the cognitive and socio-emotional processes related to EFs.

Material and Methods

Participants

We recruited fifty-three students (23 boys and 30 girls) from two elementary schools in the same urban area of the province of Almería (Spain). All participants were evaluated twice, at the beginning of the 5th grade (November) and at the end of the 6t^{h} grade (June) of Primary Education (2016-2018). At time 1 (T^1), the mean age was 9.81 years (*SD* = .48); whilst at time 2 (T^2), the mean age was 11.35 years (*SD* = .52). The participants were both monolingual Spanish speakers (*n*= 20) and Spanish speakers from migrant families (*n*= 33; 60.38%). Children from migrant families (Morocco, Romania, Portugal, and Sub-Saharan countries) were born in Spain or schooled at early ages in the Spanish educational system. For all participants, competence in the Spanish language was considered to be at the level demanded by the school curriculum.

The two participating schools were selected based upon similarities in demographic characteristics. Previously to this study, the two schools taught individualistic methodologies. At the beginning of this study (at T[1]), one of the schools applied the CL methodology over two years while the other one continued applying individualistic learning. Finally, 25 students were selected from the Cooperative leaning school, and 28 from the Individualistic Learning school (Table 1). The teachers of each participating group-classrooms in this study were interviewed to gather details about both teaching methodologies, which are shown in Table 2. Moreover, teachers reported information about their training. CL teachers (two teachers) regularly attended face-to-face and online training sessions (Teacher training center of Consejería de Educación y Deporte of Andalucía). The training was focused on knowledge of the theoretical foundation, the management of CL (implementation sequence), the learning of cooperative techniques, and planning and evaluation through CL. After training, teachers obtained a certificate of attendance and attainment. In the classroom, CL was conducted in Language, Math, and Arts subjects. Through a wide range of cooperative routines or techniques, the teachers were expected to foster cordial relationships and positive interdependence and individual accountability toward the achievement of common objectives. They promoted face-to-face interaction to develop social and interpersonal skills and provided a structure for evaluation of the CL processes (including self-evaluation, co-evaluation, and student achievements). Structurally, students were distributed in mix-abilities group of 3-4 members. The teacher in CL manages and provides resources necessary for academic achievement and tends to agree on objectives, contents, and planning aspect with the students. The students view the teacher's role as being a guide and adviser. No exams were used exclusively to evaluate student achievements. Moreover, they used final work, portfolios, and the various materials developed in class.

Teachers from the Individualistic learning school (two teachers) did not report any training or specific strategies that were developed in the classroom. Their teaching was characterized by the systematic use of a textbook. They explained a lesson by sharing a reading, and subsequently students were involved in various individual activities. Structurally, students were sitting individually without sharing any materials and activities with their classmates. A Fortnightly exam was the main tool used to assess academic achievement.

Table 1

Socio-demographic characteristics of Cooperative (CL) and Individualistic Learning (IL) groups.

		CL (n= 25)	IL (n= 28)	*Statistic*	*p*
Age	T^1	9.84 (*Sd*= .47)	9.78 (*Sd*= .49)	t = 1.48	.148
	T^2	11.44 (*Sd*= .51)	11.28 (*Sd*= .53)	t = 1.58	.123
Gender				X^2=.007	.933
	Girls	14	16		
	Boys	11	12		
Ethnic Background				X^2= 1.91	.136
Spanish		8	12		
Migrant families		17	16		

Table 2

General characteristics of the teaching methodologies in both CL and IL groups.

	CL (*n*= 25)	IL (*n*= 28)
Grouping*	Based on CL / Work groups of 3 or 4 students	Individualistic Learning / Work with peers (not systematically)
Materials/ resources	Standardized textbooks/ Laptops (at least 1 day per week) **/ Own material design.	Standardized textbooks / Laptops (not systematically used).
Activity types	Students must meet the following requirements: 1. Decide on a subject to investigate by consensus, and a final product. (e.g., a Chinese Tourist Guide). 2. Complete certain daily activities designed by the teacher (Teacher designed some basic activities based on the subject to ensure compliance with curricula contents). For instance, solve a mathematics problem about distances, or read some stories or news about different cultures. 3. Design a portfolio to record group agreements and norms, planning, activities, information, and other matters related to the project.	Students must follow the structured activities of a textbook divided into didactic units (fortnightly). Structural planning based on: 1. Introductory text about a given subject (e.g., Decimals) 2. Learning about a subject and rules (e.g., operation with decimal numbers) 3. Extension and problem-solving activities.
Knowledge evaluation instruments	Portfolio (work-group)/ Individual activities/Final Products (work-group)/ Self- and co-evaluation	Final individual exam/ Extra individual activities

* In the CL group, 14h per week of cooperative-learning methodology was implemented (in Language and Literature subjects, Math, and Arts) since not all teachers (e.g., foreign language, Science, and physical education) gave lessons using this methodology. In contrast, there were no differences in teaching methodology between teachers of the IL group.

**Laptops was used as a complementary tool for searching for information, while no special treatment was given as well as training or play.

Procedure

At both T^1 and T^2, students completed all the computerized tasks individually in a quiet room provided by the school, under the guidance of trained research assistants during a 1-hour session. The emotional intelligence and Empathy questionnaires were administered collectively in the usual classroom in a 30-minute session, after all participants had performed the computerized tasks. All personal information was treated in accordance with the Spanish personal data protection law of the 5^{th} of December 3/2018.

All the above-mentioned tasks were designed and managed on a personal computer using the software E-prime v.2.0 (Psychological Software Tools, Pittsburgh, PA).

Informed consent, in accordance with the Ethical Principles for Medical Research Involving Humans of the World Medical Association's Declaration of Helsinki, was obtained from the parents prior to both evaluations. All procedures were approved by the research ethics board of the University and by the Provincial authority of Education of the government of the Autonomous Community of Andalucía.

Measures

Executive Function Tasks

Sternberg-type task: This task evaluates the coding and maintenance of the information in WM (Stenberg, 1969). The Sternberg-type task involves presentation of a set of stimuli (between 3 and 9 consonant letters) to be memorized. On each trial, a set of stimuli is presented for a period (coding-time) which varies from 3000 to 9000 milliseconds (ms) depending on the length of the set. After a brief maintenance interval (white screen) one stimulus is presented in the center of the screen. The participant was required to indicate if the stimulus had been presented (or not) in the previous set of stimuli (Figure 1). Participants performed a practice block of 5 trials followed by 56 experimental trials. The task was programmed so that a set of stimuli (of 3, 4, 5, 6, 7, 8 or 9 letters) appeared 8 times each, 4 occasions on which the target stimulus appeared in the previous set and 4 on which it had not. We calculated the mean number of correct responses of the participants in three conditions: a) Low-load: the memorized set was 3 and 4 consonants; b) Medium-load: 5, 6 and 7 consonants; and c) High-load: 8 and 9 consonants.

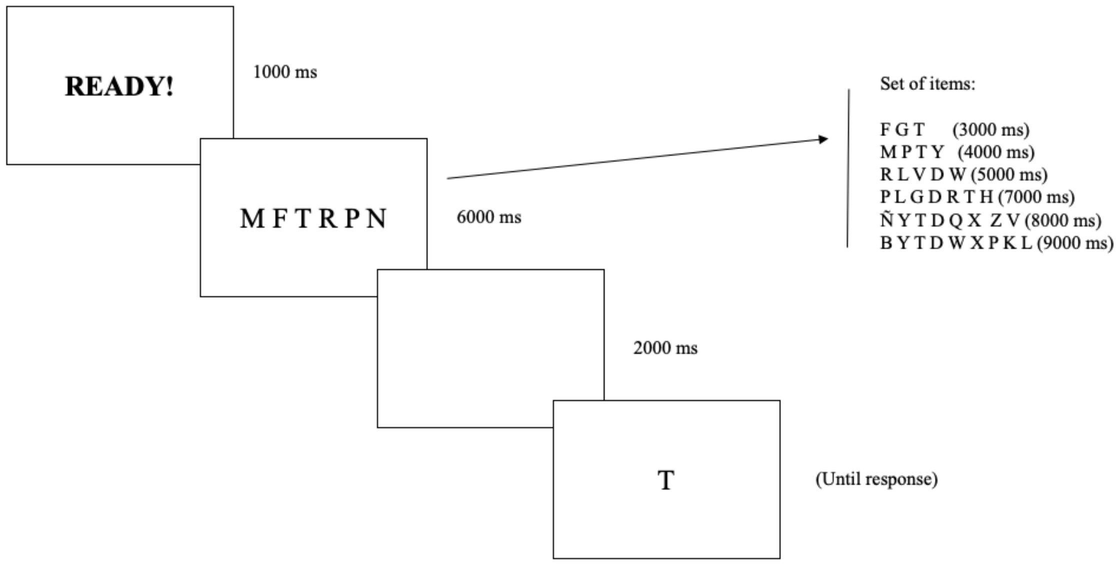

Figure 1. Schematic illustration of the Sternberg-type Task. A sequence of events on a trial of the medium-load condition. First, a message was displayed for 1000 ms to warn the child of the appearance of the stimulus set. Next, a row of 6 consonants appeared for 6000 ms (in the case of this example), followed by a delay interval of 2000 ms. Finally, a single consonant appeared in the center of the screen. Children must press ‘’m’’ on the keyboard if the stimulus appeared in the previous set of stimuli; and ‘’c’’ if the stimulus had not been presented in the previous set of stimuli.

2-back Task (Fletcher & Henson, 2001). This task evaluates key processes within the WM such as monitoring, updating, and manipulation of remembered information. A continuous stream (sequence) of stimuli is presented. For each stimulus in the sequence, participants are asked whether it matches the one presented two positions previously.

Participants must maintain and update a dynamic set of stimuli while responding to each one (Figure 2). To ensure correct understanding of the task, the participants were required to complete a practice block of 20 trials and achieve a 60% correct response rate. The task is composed of 3 blocks of 30 trials each. Therefore, a total of 90 trials are presented, of which 30 are target trials. The responses were classified as: a) *Hits* (press ''1'' in response to a target stimulus); b) *Misses* (press ''2' to in response to a target stimulus); c) *Correct rejections* (press ''2'' to in response to a non-target stimulus), d) *false alarms* (press ''1'' in response to a non-target stimulus); e) *missed responses* (trials on which the participant does not respond). The sensitivity index (or d'), a parameter of Signal Detection Theory (Stanislaw & Todorov, 1999), was calculated from the percentage of hits and false alarms.

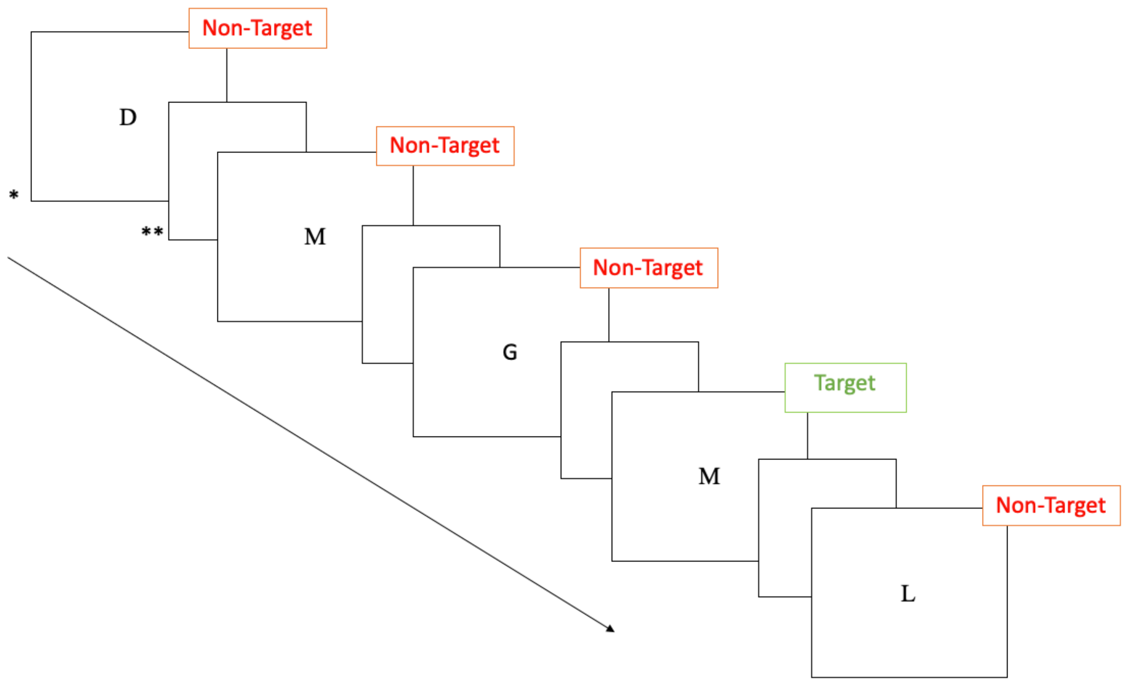

Figure 2. Schematic illustration of the 2-Back Task. Target and non-Target stimuli are shown. * Each item remains for 500 ms in the center of the screen. ** A delay period (white screen) of 3000 ms is presented between each stimulus. The participant must press the key ''1'' when detecting a stimulus that matches the one presented two positions previously (target stimulus), or key ''2'' if the item does not match (non-target stimulus).

***Child Attention Network Test* -ANT-** (Rueda et al., 2004). This study used a short version of the ANT (Child-ANT), originally developed by Rueda et al. (2004), which evaluates the efficiency of the following three attentional networks: alerting, orientating, and executive control. Children were asked to visually fixate on a central cross displayed on the computer screen. The target was a yellow fish which could appear above or below the fixation cross. By pressing a mouse button (right or left), the children had to indicate the direction in which that fish was pointing. This target fish would appear both alone (neutral flanker) or presented in the center of a row of five fish (flanker fish). The flanker fish would point in the same direction (congruent trials) or in the opposite direction (incongruent trials) with respect to the target fish. Before the target fish appeared, an attention cue was presented in three different positions: center, top and/or bottom of the screen. Participants completed a practice block of 24 trials and one experimental block of 48 trials (16 neutral, 16 congruent, and 16 incongruent). Of each of these 16 trials, 4 did not include an attentional cue; 4 included a central cue; 4 included a double cue, and 4 a spatial cue. In contrast, Rueda's version consists of 24 practice and 3 experimental blocks of 48 trials in each. Through this task we observed the children's inhibitory control of attention, that is, the capacity to selectively attend to a stimulus whilst suppressing attention to others (interference control). In this task, the interference was introduced by the incongruent flankers (16 incongruent trials). Executive control scores were calculated by subtracting the median score of each flanker condition (congruent and incongruent) from both reaction time (RT) and number of errors.

Number-Letter task (Rogers & Monsell, 1995). This task measures individual cognitive flexibility, as well as the capacity for rule switching. A symmetrical grid of four spaces is presented. On each space, a single stimulus consisting of a number and a letter will alternately appear. The participant's response varies depending on whether the stimulus appears in the two upper or lower spaces (Figure 3). The task is divided into three blocks of trials: 1) 32 experimental trials in which the stimulus always appears in the upper spaces; 2) 32 experimental trials in which the stimulus always appears in the lower spaces; and 3) 128 experimental trials in which the stimulus appears in any of the 4 spaces following the sequence from top to bottom and from left to right. Each experimental block is preceded by 12 practice trials to ensure comprehension of the task. The reaction times and the percentage of errors are recorded for the 3 blocks. This task allows us to observe the cost of switching between rules (Cost-change-task or CCT) through both reaction time (CCT^{RT}) and percentage of errors (CCT^{E}). CCT^{RT} was calculated by subtracting the mean RT of Block-1 and Block-2, from the mean RT of Block-3. The CCT^{E} was calculated by subtracting the percentage of errors in Block-1 and Block-2 from the mean percentage of errors in Block-3.

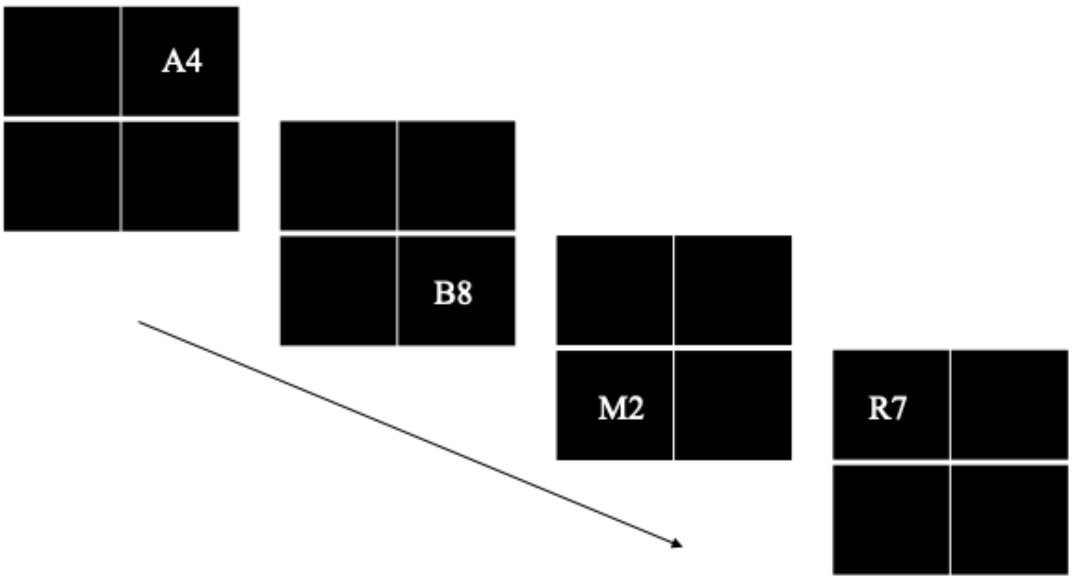

Figure 3. Examples of Block-3 trials in the Number-Letter task. When a stimulus appears in the upper spaces, the participant must respond by pressing the corresponding key according to whether the number is odd (n) or even (m). When the stimulus appears in the lower spaces, the participant must indicate whether the letter is a vowel (z) or consonant (x). The stimulus remains in each space until the participant responds.

Tower of Hanoi (Borys, Spitz & Dorans, 1982). This is a computer-based task which evaluates planning capacity. We used a computerized version developed by Groot (2004). The aim of this task is to move three disks of different sizes by three rods (Figure 4). Children are shown a model which they must create in a certain number of movements (from 2 to 7 movements). The children must perform 2 practice trials to ensure understanding of the rules. Subsequently, the children are given 10 experimental trials divided into two blocks: 5 for short-planning (requiring less than 5 movements) and 5 for long-planning (requiring more than 5 movements). The mean number of errors is recorded for each condition.

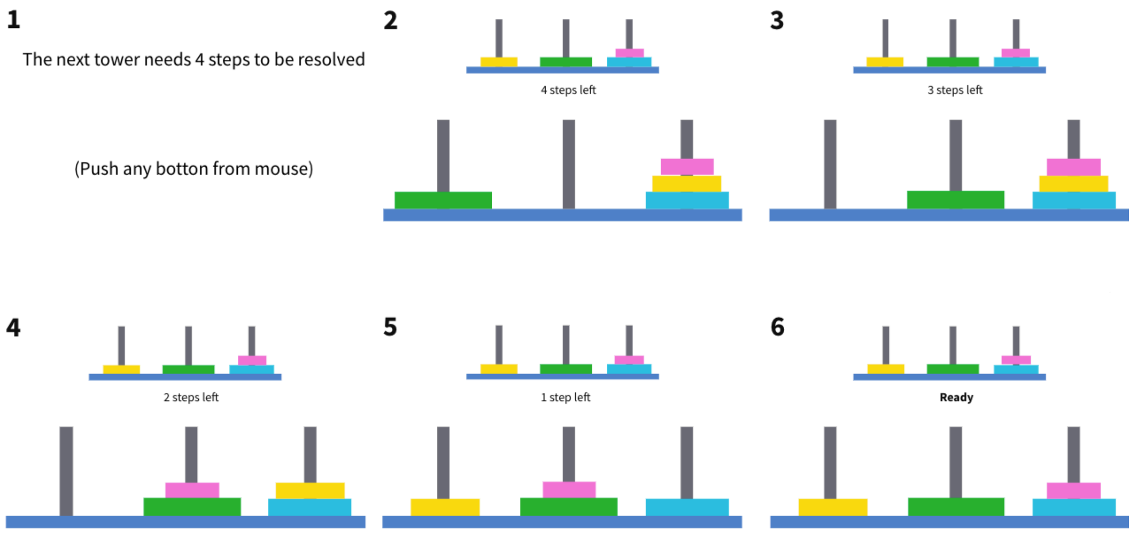

Figure 4. Tower of Hanoi sequence for a four-step task (low planning condition). A first message (1) appears showing the steps that are necessary to complete the task. An upper model is then presented which must be reproduced in the model at the bottom (2). Participants must use the mouse to move every single piece until completing the model (steps 3, 4, 5 and 6). Basic rules: a) only one disk can be moved at a time; b) one disk cannot be placed on top of a smaller one; and c) Only the disks on top of each rod can be moved. An error message appears if the child makes a mistake, after which they must begin the task again.

Emotional Intelligence and Empathy measures

Socio-emotional intelligence test (SEIT). This is a socio-emotional intelligence questionnaire developed by Chiriboga and Franco (2001), which consists of 60 items grouped into five dimensions: *self-awareness*, which is the perception and understanding of one's own emotions; *self-control*, the ability to regulate emotions and adapt behaviors to different contexts; *self-motivation*, the intrinsic motivation to guide efforts towards a goal; *empathy*, the ability to understand and recognize the emotions of others; and *social skills*, a set of abilities that facilitate and allow for adaptation to the group. The children were asked to rate each item on a 4-point Likert-type scale (0= never, 1= sometimes, 2= most of the time, 3= always). This scale indicates that the higher the score, the better the perception and understanding regarding the dimensions evaluated. The estimated time needed to complete the test is 30 minutes. For this study, we used the partial scores of each scale and the total score obtained by the sum of all items. Concerning the validity of the questionnaire, the authors reported a sensitivity of 45%, and a specificity of 75%; with the positive and negative predictive values being 34% and 83% respectively. The questionnaire showed an adequate internal reliability of 69% (Chiriboga et al., 2001).

Spanish short version of the Basic Empathy Scale (SV-BES). The 9-item test used in this study was adapted by Oliva et al. (2011) based on an original scale developed by Jolliffe et al. (2006). This self-report instrument uses a 5-point Likert-type scale (1= strongly disagree; 2= disagree; 3= neither agree nor disagree; 4= agree; 5= strongly agree). This scale indicates that the higher the score, the better the perception and understanding regarding the dimensions evaluated. The estimated time needed to complete the scale is 5 minutes. The items are grouped into two dimensions: affective empathy (Items 1, 2, 3 and 6); and cognitive empathy (Items 4, 5, 7, 8 and 9). The overall score is calculated through the simple sum of all items. The Cronbach`s alpha internal consistency coefficients reported by Merino-Soto and Grimaldo-Muchotrigo (2015) were .77 (affective empathy) and .76 (cognitive empathy).

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) v. 23.0 (IBM Corporation, Armonk, NY, USA). Intergroup and intragroup analyses were performed. To identify the differences between T^1 and T^2 in the *cool* and *hot-EF* measures, we used the student's *t* test. In order to identify the possible influence of teaching methodology on the development of *cool* and *hot-EFs*, we conducted a 2 (CL group, IL group) x 2 (T^1, T^2) mixed ANOVA for each variable. Statistical significance was set at $p \leq 0.05$, and trending towards significance was defined as $p \leq 0.08$. When appropriate, post hoc comparisons were made using Sidak's test. One participant was excluded from the analysis of the ANT for being identified as an outlier. Similarly, three students were excluded from the analysis of the Number-Letter task for the same reason.

Results

Development of Executive functions across late childhood

In order to examine the longitudinal development of *cool* and *hot-EFs,* we carried out Student's *t* tests to compare T^1 and T^2 for each variable. As expected, changes in the performance of executive tasks were observed between the two evaluations (Table 3). Regarding WM, we observed significant improvements on the 2-Back task ($p < 0.01$) and Sternberg task medium-load condition (when the stimulus set is 5, 6 and 7 consonants; $p < 0.01$) at T^2 compared with T^1. Significant improvements were also observed on the cognitive flexibility task (Number-Letter Task) for both CCT^{RT} ($p < 0.001$) and CCT^{E} ($p <$

0.01). The analysis revealed improved performance on the Tower of Hanoi task in the long condition (trials requiring more than 5 movements) but no changes were observed in the short condition (trials requiring less than 5 movements). No statistically significant differences were observed in the ANT.

Regarding EI, we observed no significant changes across T^1 and T^2 in SEIT and SV-EBS (affective and cognitive empathy).

Methodology: Cooperative Learning vs individualistic learning

Descriptive statistics of all variables for each group (CL and IL) are described in Table 4, including mean scores and standard deviations at T^1 and T^2, and significant differences between tests. First, we conducted a one-factor ANOVA for each variable at T^1 in which we observed no pre-existing differences between the group-classrooms at T^1. Second, a 2 (CL group, IL group) x 2 (T^1, T^2) repeated-measures ANOVA for each variable was conducted to identify the possible influence of teaching methodology on the development of EFs (Cool and Hot), and found an interaction on the Sternberg task. The ANOVA revealed a significant interaction in the high-load condition, and a tendency toward significance in the low-load condition (Table 4). Post-hoc analysis indicated that the CL group showed significant improvement on the Sternberg task (WM) in both low and high-load conditions between T^1 and T^2 ($p < .05$). The difference between evaluations in the IL group was not significant ($p = .504$). However, in both low and high-load conditions, the scores worsened from T^1 to T^2. Both groups showed statistically similar performance scores on the Sternberg task (high-load condition) at T^1 ($p = .171$), although the students in the CL group started from lower levels ($m = 71.52$) than those in the IL group (m=76.89). It should be noted that at T^2 the CL group reached a similar level (m= 80.04) to that of IL at T^1 (m= 76.89).

Table 3.

Descriptive Statistics and Student's t Test Comparisons of T^1 and T^2 for all Measures.

	T^1				T^2						
	M	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*	*t*	*df*	*Cohen's d*
Age	9.81	.48	9	11	11.35	.52	10	12	-22.41***	52	-
2-Back-Task											
d'	1.31	.72	-.25	2.87	1.73	.87	.13	3.63	-3.25**	52	.58
Sternberg-Task											
Low-load	93.01	11.49	50	100	95.01	10.3	50	100	-1.13	52	.17
Medium-load	82.19	12.15	50	100	88.09	8.99	54.3	100	-3.44**	52	.49
High-load	74.36	14.18	44	100	77.26	11.41	56.5	100	-1.23	52	.20
Number-Letter											
CCT^{RT}	1445.38	1064.23	-2760.55	3275.77	963.81	678.85	-678.68	2892.57	3.64***	49	.45
CCT^{E}	6.7	10.24	-15.5	44	2.87	6.29	-5.5	30	2.78**	49	.37
ANT											
EC^{RT}	79.42	118.17	-162.50	383.50	41.38	85.66	-225	236	1.72	51	.32
EC^{E}	3.09	11.83	-37.00	37.00	2.13	7.93	-25	25	0.47	51	.14
Tower of Hanoi											
Short-Planning	.33	.50	.00	2.4	.24	.32	.00	1.4	1.16	52	.18
Long-Planning	2.63	1.43	.6	7.4	1.44	.8	.4	4	5.72***	52	.83
SEIT											
Self-Awareness	23.72	6.07	2	34	25.17	4.62	15	33	-1.68	52	.23
Self-Control	21.75	5.14	3	31	22.74	4.17	13	31	-1.10	52	.19
Self-Motivation	26.81	5.58	12	35	27.92	4.81	18	36	-1.37	52	.19
Empathy	25.47	6.21	7	35	25.72	5.14	14	34	-.25	52	.04

Social-Skills	26.49	6.53	5	36	27.34	4.55	15	36	-.92	52	.13
Total	125.06	26.38	43	183	128.89	18.09	95	162	-1.03	52	.15
SV-EBS											
Affective	14.4	3.77	7	21	14.04	3.06	4	19	.64	52	.1
Cognitive	20.47	2.98	11	25	19.75	3.42	11	25	1.18	52	.22

Note. CCT^{RT}, switching cost for reaction time; CCT^{E}, switching cost for errors; EC^{RT}, Executive control for reaction time; EC^{E}, Executive control for errors; SEIT, Socio-emotional Intelligence Test; SV-EBS, Short Version of Empathy basic scale.

**p* < 0.05; ** *p* < 0.01; ** **p* < 0.001.

Table 4.

Descriptive Statistics of all variables at T^1 and T^2 for each group.

Evaluation	CL group (*n*= 25)		IL group (*n*= 28)		*F (Df)*	*p*
	T^1	T^2	T^1	T^2		
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*		
Age	9.84 *(.47)*	11.44 *(.51)*	9.79 *(.5)*	11.29 *(.53)*	-	-
2-Back-Task						
d’	1.31 *(0.78)*	1.86 *(0.82)*	1.3 *(0.68)*	1.61 *(0.9)*	.92 *(1,51)*	.34
Sternberg-Task						
Low-load	91.58 *(13.91)*	97.1 *(4.36)* *	94.28 *(8.88)*	93.14 *(13.41)*	3.74 *(1,51)*	.06
Medium-load	84.35 *(13.48)*	88.52 *(6.19)*	80.27 *(10.72)*	87.7 *(11.01)*	.9 *(1,51)*	.39
High-load	71.52 *(13.15)*	80.04 *(10.22)* *	76.89 *(14.8)*	74.78 *(12.01)*	5.43 *(1,51)*	**.024**
Number- Letter						
CCT^{RT}	1338.64 *(905.10)*	937.28 *(586.79)*	1543.92 *(1202.15)*	988.3 *(764.96)*	.34 *(1,48)*	.56
CCT^{E}	6.79 *(12.94)*	1.9 *(4.6)*	6.61 *(7.16)*	3.77 *(7.5)*	.55 *(1,48)*	.46
ANT						
EC^{RT}	92.48 *(131.13)*	38.23 *(94.19)*	68.23 *(107)*	44.1 *(79.29)*	.45 *(1,50)*	.5
EC^{E}	6.21 *(12.95)*	2.58 *(7.5)*	0.43 *(10.29)*	1.75 *(8.41)*	1.44 *(1,50)*	.24
Tower of Hanoi						
Short-Planning	0.4 *(0.6)*	0.21 *(0.33)*	0.27 *(0.4)*	0.28 *(0.32)*	1.8 *(1,51)*	.18
Long-Planning	2.57 *(1.45)*	1.29 *(0.66)*	2.69 *(1.44)*	1.58 *(0.89)*	1.4 *(1,51)*	.71
SEIT						
Self-Awareness	23.96 *(4.68)*	24.84 *(4.57)*	23.5 *(7.18)*	25.46 *(4.74)*	.39 *(1,51)*	.54

Self-Control	20.72 *(3.91)*	23.8 *(2.99)* **	22.68 *(5.95)*	21.79 *(4.74)*	5.4 (*1,51*)	**.024**
Self-Motivation	26.04 *(5.13)*	27.52 *(5.07)*	27.5 *(5.96)*	28.29 *(4.63)*	.18 (*1,51*)	.67
Empathy	24.84 *(4.17)*	24.6 *(5.78)*	26.03 *(7.62)*	26.71 *(4.35)*	.22 (*1, 51*)	.64
Social Skills	26.76 *(5.26)*	26.4 *(4.31)*	26.25 *(7.58)*	28.18 *(4.67)*	1.54 (*1,51*)	.22
Total	122.32 *(17.71)*	127.16 *(18.37)*	127.5 *(32.38)*	130.43 *(18.04)*	.06 (*1,51*)	.8
SV-EBS						
Affective	13.88 *(3.72)*	13.12 *(2.93)*	14.86 *(3.83)*	14.86 *(2.98)*	.46 (*1,51*)	.5
Cognitive	20.12 *(2.18)*	19.84 *(3.1)*	20.79 *(3.56)*	19.68 *(3.73)*	.46 (*1,51*)	.5

Note: CCT^{RT}, switching cost for reaction time; CCT^{E}, switching cost for errors; EC^{RT}, Executive control for reaction time; EC^{E}, Executive control for errors; EBS, Empathy basic scale.

Bold type indicates significant interactions between methodology and EF development.

Differences between T^1 and T^2 in each group: * $p<0.05$, ** $p<0.01$

We also found a significant interaction between methodology and the self-control subcomponent of the Socio-emotional intelligence test (SEIT). Post-hoc analysis indicated that the CL group showed significant gains in self-control between T^1 and T^2 ($p < .05$) while these improvements were not observed in the IL group ($p = .451$). No interactions were found for the remaining variables.

Discussion

The main aim of the present study was to analyze the development of *cool* and *hot-EFs* at two different times between the 5th and 6th grade of Primary School. Our first hypothesis predicted significant changes in *cool* (WM, cognitive flexibility, inhibitory control, and planning) and *hot-EFs* (socio-emotional intelligence and empathy) throughout this period, as well as changes in WM, cognitive flexibility, inhibitory control, and planning measures. Our findings revealed significant age-related improvements between T^1 and T^2 in WM (2-back and Sternberg-type tasks), cognitive flexibility (Number-Letter task) and Planning (Tower of Hanoi task), while no differences were found in Inhibitory control (ANT; Executive control: EC^{RT} and EC^{E}). These results are consistent with those of previous studies suggesting that significant changes can be found in WM task performance throughout middle and late childhood (Conklin et al., 2007; Gathercole et al., 2004; Luna et al., 2004). In particular, these findings are in accordance with studies that indicate an increase in proficiency in maintaining/updating performance as measured through N-Back tasks (e.g., Ciesielski et al., 2006; Vuontela et al., 2003). Pureza et al. (2013), using this general paradigm, employed two different 2-back tasks (both auditory and visual). The authors found significant differences between three age groups: 6-7, 8-9 and 11-12 years. Further, we used a verbal task (Sternberg-type task) to assess the coding and maintenance of information in WM. This task consists of three load conditions in which different components of WM are involved, depending on the extent of the load. Considering that activation of the various WM components (i.e., phonological loop and central executive system) depends on the demands of the task (Rypma & D'Esposito, 1999), these results suggest that performance on the trials in which the phonological loop is engaged (low-load condition: trials of 3-4 items) remains stable across T^1 and T^2 (93.01% and 95.01% correct responses, respectively). In contrast, performance on the two conditions in which the capacity of the phonological loop was exceeded (trials of more than 4 items; medium and High-load condition)— thus recruiting the strategic processes of the central executive system — did not remain stable across the two ages. In fact, we found significant differences between T^1 and T^2 for the medium-load condition (the condition that involves a load of 5, 6, and 7 items). Nevertheless, no changes were found in the high-load condition between T^1 and T^2 (74.36% and 77.26% correct responses respectively), the performance of which could also depend on the central executive system. These findings are congruent with those of other studies indicating that age is positively related to overall performance on verbal WM in middle and late childhood (Brocki & Bohlin, 2004). In a large sample of children aged from 4 to 15 years, Gathercole et al. (2004) found linear increases up to adolescence in scores on WM measures (verbal and non-verbal tasks) associated with the phonological loop, the central executive system, and the visuospatial sketchpad. In our study, the significant improvements in the medium-load condition and no changes in the high-load condition led us to assume that there may be scope for development of the central executive system beyond childhood. It would, however, be necessary to use specific measures to explore the independent developmental changes in the phonological loop and the visuospatial sketchpad.

Our results also suggest age-related changes across T^1 and T^2 in cognitive flexibility (Number-letter-task), as measured by both reaction time (CCT^{RT}) and the percentage of errors (CCT^E). Our findings are supported by previous studies in which changes in performance on task-switching paradigms are associated with changes over time (Davidson et al., 2006; Dick, 2014). Similar to our study, Cragg and Nation (2009) conducted a study with a large sample of children aged between 5 and 11 years. They found that the switching cost (both RT and accuracy) improved significantly with age. These findings indicate that the ability to flexibly switch between two task sets develops during this period, with mid-childhood being a transition period where developmental changes occur that persist until adulthood (Crone et al., 2004).

Further, our study has yielded evidence in relation to the development of planning skills. The difference in performance between T^1 and T^2 was significant on those trials that required longer planning strategies, with a large effect size (r= .67). Our findings are congruent with those reported in the study by Luciana et al. (2009), which demonstrated significant age-related differences in the performance of planning tasks (e.g., Tower of London) in a sample aged between 9 and 20 years. Their results revealed that younger participants performed worse than adults as the number of moves to complete each problem set increased, although in the lower levels of complexity (2-3 movements; short-planning) the youngsters performed the task at the same level as adults. Planning is considered to be a higher-order skill that develops with core EFs (WM, cognitive flexibility, and inhibition; Miyake et al., 2000). This skill improves significantly throughout the early years and supports other processes such as theory of mind or problem solving (Carlson et al., 2004; Simon, 1975).

We found no changes in inhibitory control between T^1 and T^2 when measured by a short version of the ANT for children (Child-ANT). This finding is in accord with those reported by Rueda et al. (2004), which confirmed that this skill develops from the age of 4 to 6 or 7 years. However, no significant differences are found in interference control (interference introduced by the incongruent flankers) between the age of 7 years and adulthood. In fact, one of the key findings of this study was the similar effects of flanker interference found in 10-year-old children and adults when the entire sample was assessed using ANT in both its adult and child versions, although the adult version appeared to be more challenging for children. Similarly, Ridderinkhof et al. (1997) found improvements in interference control in a flanker task between the ages of 5 and 10 years but no significant differences between the age of 10 years and adulthood. While these studies support our findings (which appear to be widely documented), more research is needed to determine the standard age at which executive control reaches adult levels.

Finally, no changes were observed in the scores on emotional self-report questionnaires (SEIT and SV-EBS). The EI dimensions assessed in this study imply a broad range of proficiencies, and subjective self-perceptions and self-concept (*awareness*, *control*, *motivation*, *social-skills,* and *empathy*). Our findings are supported by the results of other longitudinal studies which have shown no developmental changes beyond middle and late childhood (Byrne & Shavelson, 1996; Keefer et al., 2013), suggesting that the structure of personality and self-concept related to EI traits already resembles that of adults (Soto et al., 2008). Moreover, empathy is a prosocial behavior-related construct that is influenced by various factors (e.g., the home environment; Thompson & Gullone, 2003). In contrast with whose studies that indicate age-related changes throughout late childhood (e.g., Geng et al., 2012), we did not observe changes in measures of empathy (SV-EBS) in either its cognitive or affective dimensions. Based on the results of their meta-analysis, Fabes et al. (1999) claim that age differences in empathy and other prosocial behaviors could vary depending on the design of the studies. Therefore, our results are not conclusive since the magnitude of age differences could be determined by the type of EI measurement used (including the empathy questionnaire) and the sample size. Therefore, further longitudinal studies are needed to understand the development and stability of empathy and EI with the passage of time, and to determine which periods are critical for observing individual differences throughout childhood.

We also predicted that children involved in CL as a classroom methodology would significantly improve in terms of the cognitive and socio-emotional processes related to EFs in comparison with IL children. Our results indicate that there were significant differences associated with CL across ages in certain executive components. On the Sternberg task, the CL group showed significant gains between T^1 and T^2 in both high-load conditions (previous stimulus set composed of 8 and 9 consonants). Significant differences were also found for the self-control sub-component of EI. Previous educational studies have confirmed the efficacy of specific interventions that contribute to social development and cognitive control (Barnett et al., 2008; Diamond et al., 2007). Our findings are consistent with these recent studies indicating that curricular differences can have a significant impact on children's EFs. Moreover, these results are in line with those reported by Gabbert et al. (1986), who analyzed the effects of CL in a school context. They observed that cooperative groups performed better than individualistic-learning children on certain cognitive tasks that have been traditionally linked to EFs, particularly WM (reasoning, problem solving; Logie et al., 1994). Although no specific studies have shown associations between CL and Self-control, some authors claim that CL reinforces social skills such as interpersonal trust and positive interdependency, communication, mutual support and attentiveness, more positive self-esteem, and greater acceptance of oneself (Gillies, 2014; Johnson, 1980). The particular features of this methodology such as interaction between teacher and student (e.g., management strategies), student-student interaction (e.g., grouping, role-playing), and the use of specific strategies (e.g., working routines) may be factors that mediate the development of certain cognitive skills or performance on specific cognitive tasks. As shown by our findings, the use of CL as a classroom methodology in Primary School could be a potential strategy for promoting executive processes and could explain the gains in EF experienced by the CL group in terms of WM and self-control. CL places the student at the center of the process (as an active agent who makes his/her own decisions) the purpose of which is to increase motivation towards one's own learning, which is an essential element in the teaching-learning process and EF development (Gottfried, 1990; Zelazo & Carlson, 2012).

Although these findings contribute to our understanding of the development of EFs and their relationship with classroom methodology, this study has certain limitations. First, our measurement of executive functioning related to emotional processes was based on an emotional self-report questionnaire, the responses of which could be affected by subjectivity bias. In accordance with the relational perspective of Main et al. (2017), in which the authors highlight the complex and indivisible relation between individual and context, we suggest that future studies should have a more ecological assessment approach by using tasks that assess individual characteristics in everyday life situations and decision-making scenarios (e.g., Children's Gambling Task; Delay of Gratification tasks), which could contribute towards observing performance on emotionally-charged tasks (e.g., risk taking, quality of decision-making, decision time, risk adjustment, delay aversion, and impulsivity).

Further, use of the emotional self-perception questionnaire could be a limitation for migrant children since self-perception of emotion implies the abstraction of complex ideas, which could depend on a high level of linguistic competence. A questionnaire administered to observer-informants (parents and teachers) could be used to avoid this bias. It would also be useful to gather information on academic performance (Average grades), or family context (socio-economic level, parents' educational level, home-habits) which would extend the possibilities for exploring the various factors that could be involved in the development of EFs. Moreover, the sample size in this study could be regarded as small. Thus, a larger sample would ensure more consistent results and would allow us to make a more accurate diagnosis of the development of EFs throughout late childhood. Another limitation was the partial implementation of CL. The CL group was only involved in cooperative learning activities for the main subjects of Language and Literature, Mathematics and Arts (12 h per week) due to the school timetable, while the individualistic approach was applied most of the time. Therefore, we suppose that further exposure to the CL methodology might have generated more marked results in this group.

Conclusion

Our study has revealed developmental changes in WM, cognitive flexibility, and planning (*cool EFs*) across childhood (the last stage of Primary School); whilst no significant changes were found for inhibitory control (ability to resist interference from distractors in a conflict task) and *hot-EFs* (Emotional Intelligence and empathy). The CL methodology was found to be associated with improvements in WM and self-control. Therefore, our results suggest that classroom methodology can play an important role in ensuring the adequate development of cognitive and socio-emotional skills. The findings of this longitudinal study have important implications for psychological, neuroscientific, and educational research. In particular, we have provided novel data regarding the development of *cool* and *hot-EFs* during the last stage of Primary School. Moreover, we have observed how CL could be associated with the development of *cool* and *hot-EFs*, at least in the sample studied here. Consequently, new educational proposals and research based on our findings are necessary to observe changes during this period in which children face very significant and decisive changes at both a cognitive and socio-emotional level.

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Age-related changes in creative thinking during late childhood: the contribution of Cooperative Learning

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Thinking skills and creativity (En revisión)

Abstract

Creative thinking has been considered a human skill that is necessary for facing challenging situations that require adaptive solutions. From an educational perspective, creative thinking plays an important role in learning processes and is an issue of central importance within classroom methodology. In this regard, Cooperative learning (CL) has been studied as a methodology that enhances creative processes. CL methodology refers to teaching procedures based on organizing the class into small mixed-abilities groups where students work cooperatively to complete academic tasks and consolidate their learning. However, the impact of CL on creative thinking seems to have been insufficiently explored in late childhood, which is known as a transitory stage between childhood and adolescence. Using two tests (at 5th and 6th grades of Primary School), we examined the trajectory of creative thinking in fifty-three students from two different schools. Students were assessed by a divergent thinking task (CREA Test; Corbalán et al., 2015) at two time points: Test-1 (T^1), with a mean age of 9.81 years (*Sd*= .48), and Test-2 (T^2), with a mean age of 11.35 years (*Sd*= .52). Given the differences in methodology delivered in each school (Cooperative and individualistic learning), we also analyzed the effects of this variable on student creative thinking performance. We found significant improvements between testing in the two schools, although CL appeared to have a more positive effect than IL on creative thinking performance. Our finding highlights the importance of studying classroom methodology as a mediating factor in creative thinking development, which could be important in the learning processes as well as the integral development of the child.

Keywords: Cooperative learning, Creative thinking, Divergent thinking test, Classroom methodology.

Abbreviation: Cooperative Learning (CL), Individual Learning (IL), Test 1 (T^1), Test 2 (T^2).

Introduction

In recent decades, educational institutions have highlighted the importance of preparing for a future landscape that will require students to have more complex problem solving and creative thinking skills (Richardson & Mishra, 2018). A creative and adaptive mind is necessary to learn and integrate new knowledge and develop original and novel ideas. Furthermore, creative thinking helps children develop coping and adaptive thinking strategies (Behnamnia et al., 2020). The study of creative thinking across childhood and adolescence has been linked to certain factors that are influential for development. Therefore, creative thinking is considered a construct that does not develop in isolation and requires support from the environment (Glăveanu, 2015).

Much research has been conducted on the effect of contextual factors that mediate creative thinking such as family characteristics or educational settings (Jankowska & Karwowski, 2019; Navarrete, 2013; Navarro & Chacón-López, 2021). However, although it is widely accepted that contextual factors contribute to creative thinking development, the mediating role of teaching practice (e.g., methodologies, learning resources, or classroom experiences) has received relatively less attention in empirical research. Despite this, previous studies focusing on the effect of teaching methodologies on creative thinking in the child school population have reported that creative thinking skills could be promoted through structured methodologies such as Cooperative Learning (CL; Marashi & Khtami, 2017; Segundo et al., 2020).

The present study examined the longitudinal development of creative thinking in early adolescence over a period of two years. Moreover, we explored the effect of CL as an integrated methodology (Cooperative and individualistic learning) in day-to-day classroom practices across the last stage of primary school.

Creative thinking

Generally, creativity is defined as a set of abilities necessary to deal with challenging or unknown situations requiring novel and appropriate ideas (Torrance, 1972). Through creative thinking processes, individuals combine elements, perceive, understand, and generate new ideas, and share the results. Creative thinking skills are inherent in the generative and adaptive nature of human thought (Wang, 2012; Ward, Smith, & Vaid, 1997). Further, creative thinking has been linked to specific individual characteristics. For example, Corbalán et al. (2015), for the educational context, suggest that high performance in creative thinking is characterized by flexible and adaptive skills, along with a proactive and curious approach to learning. Consequently, creative thinking is considered a central skill for learning.

Traditionally, children's creativity has been measured by divergent thinking tests (i.e., Torrance Test of Creative Thinking), which have shown to be reliable predictors of a child's potential for creative thinking (Runco & Acar, 2012). Divergent thinking refers to the capacity to establish links between unrelated ideas from different categories and propose multiple solutions to a problem (Guilford, 1967). Divergent thinking has been conceptualized in terms of four basic components: fluency, flexibility, elaboration, and originality (Torrance, 1966). Fluency is defined as producing ideas and generating alternatives or solutions to a given problem. In the classroom context, this ability is relevant when the teacher asks the students to propose as many ideas as possible for introducing a new lesson or project (i.e., Brainstorming). Flexibility is the ability to use different categories of relevant responses, which means approaching problems from different angles. For instance, a teacher asks students to invent an alternative ending for a story or draw objects as a surrealist would. Elaboration is the capacity to add and build new elements upon a previous idea. For example, in a writing class, the teacher can ask students to incorporate new characters into a story or add components to a picture.

Finally, originality refers to the capacity to generate uncommon responses. For instance, in an art activity, the teacher might ask students to make a collage to represent a song (Shively, 2011; Wechsler, 2006).

Kaufman and Beghetto (2009) describe the individual creative process (based on the Vygotskian learning approach) as constructing personal knowledge and understanding within a particular social and cultural context. Within this paradigm, creative thinking is as an extension of the thinking and problem-solving aspects of student learning. This means that creative thinking processes require learners to use all kinds of thinking abilities to solve problems and adapt to the context and not only focus on the result of learning (e.g., curricular contents), but also on processes that imply the generation of experiences and cognitive strategies useful for the future of learners (Shi et al., 2010).

Creative thinking development

The developmental trajectory of creative thinking during childhood has been studied for decades. Although the results are inconclusive, various studies suggest that creative thinking fluctuates ("slumps and jumps"). Studies conducted with preschoolers have found that an increase in creative thinking occurs from the early years. Bijvoet-van den Berg & Hoicka (2014) found a significant increase in performance on a divergent thinking test between the ages of 2 and 4 (Unusual Box Test). Similarly, Chae (2003) found a significant increase between the ages of 4 and 5 in the Test for Creative Thinking – Drawing Production (TCT- DP); however, no differences were found between the ages of 5 and 6. Torrance (1968) conducted the earliest study on the creative thinking trajectory in primary school children. This author assessed children in three different periods across third, fourth, and fifth grades of primary school and observed a greater decline in performance between third and fourth grade in all components of divergent thinking (Fluency, elaboration, flexibility, and originality); however, a subsequent increase was observed between fourth and fifth grade. This increase seems to be maintained, at least, between the ages of 10 and 11 (Smith & Carlsson, 1983). Gralewski et al. (2016), in an extensive study with a diverse sample (n= 4898) aged between 4 and 21 years, found that creative thinking measured through a divergent thinking test (TTCT-DP) increased progressively from the age of 4 to 14. During this period, decreased variations (although non-significant) were found at 7, 11, and 13 years. These results indicate that there are several "slumps and jumps" in the development of creative thinking across childhood. In this sense, Torrance (1968) suggested that these observed slumps and jumps were due to the child's adaptation to classroom expectations. Moreover, this author postulated that social interaction pressure plays a determining role in the display of creative abilities. Therefore, the various learning scenarios throughout the school years could be critical in the development of creative thinking. In other words, the school context (e.g., methodology, social interactions) could boost or weaken creative thinking development (Bonawitz et al., 2011; Hoicka & Akhtar, 2011).

The development of creative thinking could not be understood without cognitive abilities (e.g., Executive Functions). Developmental studies indicate that the processes implicit in creative thinking are linked to the child's neurocognitive development (Ramírez et al., 2017). This suggests that creative thinking is a complex construct that could undergo critical phases that are related to the development of cognitive processes during childhood. Studies suggest that the development of creative thinking oscillates (declines and increases) when other aspects of cognition are developing (Lubart & Georgsdottir, 2004). Karmiloff-Smith's model (1994) also posits the existence of "mismatches" between these two constructs throughout childhood. This model maintains that a temporary regression in creative production would occur once the child acquires new skills. Once these skills have been consolidated, creative thinking processes are reestablished based on the new knowledge acquired.

We could conclude that children increase their creative thinking abilities as they get older due to their cognitive maturation and the enrichment of their educational and social experiences. However, due to the large number of factors that can contribute to the development of creative thinking, we cannot draw definitive conclusions. Therefore, future studies should focus explicitly on this matter.

Creative thinking development and Cooperative learning

Almost no studies have focused exclusively on the development of creative thinking across early adolescence. However, due to its very nature, this construct has been studied in terms of multiple determining factors including educational setting, family care, social status, or developmental cognition (Jankowska & Karwowski, 2019; Lucchiari et al., 2019; Zhou, 2021). Therefore, previous studies have focused mainly on the effect of these factors, as opposed to explicitly observing developmental changes over time.

The classroom environment is traditionally a space where strategies can be implemented to enhance the development of creative thinking (e.g., Moeller et al., 2013; Zhu, 2010). In particular, the mediating effect of teaching methodologies has been widely studied among researchers within creative thinking development. According to studies conducted in school environments, creative thinking development arises from the interaction between contextual and individual factors (Zhang et al., 2020). In this regard, teachers (as well as teaching methodologies) play an important role as an environmental factor in developing students' creative thinking in early adolescence (Hong et al., 2009; Sho, 2017). Cropley (1995) has highlighted certain teaching practice characteristics (e.g., teaching methodology or creative environments for learning) that are necessary for favoring the development of creative thinking. These characteristics include promoting autonomy towards learning and the self-assessment of students; offering the opportunity to generate different actions for learning in a wide variety of conditions or scenarios; and encouraging a cooperative and socially integrative style of teaching.

CL is a methodology based on the social cognition principles of Vygostky (1978), who considered social interaction (parents, peers, teachers, etc.) to be a mediator of learning and cognitive development. The methodological approach of CL focuses on the pedagogical practice whereby students can work together in small heterogeneous and mixed ability groups and experience positive social interaction to accomplish a shared and common learning goal. CL is based on the principles of diversity, individual needs, and students' learning patterns (Johnson & Johnson, 2002; Siegel, 2005).

Contrary to other group methodologies that do not necessarily imply cooperation (ordinary group work), CL uses a wide range of routines or techniques for group management to ensure the development of the five elements that underpin this methodology (Johnson and Johnson, 2009). These elements are 1) *Positive interdependence,* in which the classroom climate is based on cordial relationships and the constructive handling of conflicts; *2) Individual accountability* which refers to the efforts made by the students toward achieving common objectives; 3) *Face-to-face promotive interaction*, which encourages students to place themselves face to face to interact verbally. Therefore, this is an appropriate group configuration for interacting with members of the group through dialogue, debate, interviews and questioning; 4) *Social and interpersonal skills,* which includes promoting leadership attitudes, a climate of trust, communication, respect, and peer cooperation; and 5) *Group processing*. CL proposes a structure for evaluation, including self-evaluation, co-evaluation, and teacher evaluation of student attainment. In self-evaluation and co-evaluation, the members analyze each other's participation and accountability, assess the strategies most effective in the process of learning, and reach a consensus for modifying these strategies (Kyndt et al., 2013).

Developmental research suggests that CL is a teaching methodology that enhances creative thinking. The methodological characteristics of CL help students to use more varied reasoning strategies (problem-solving strategies and divergent thinking) to find novel solutions and to generate original ideas (Hattie, 2009). For example, Segundo et al. (2020) used a pre-test/post-test design in Primary School to compare performance on a verbal creative thinking test (CREA Test) between two groups: CL vs. Standard Learning (control group). The results revealed that children involved in CL methodology significantly improved their performance in creative thinking across time, while the control group did not show such improved performance between tests. Similarly, studies have been conducted at different educational stages. For example, in a quasi-experimental pre-test and post-test control group design conducted with preschoolers, Siew et al. (2017) found that CL had a significant positive impact on creative thinking skills. The authors argued that the children were involved in thinking and discussion processes through CL strategies that promote many uncommon or original responses. Moreover, Marashi & Khatami (2017) found that systematic use of cooperative techniques (e.g., think-pair-share, three-stay one-stray, roundtable, and three-step-interview) significantly improved the creative thinking of students (in middle childhood and adolescence).

Thus, by using a diversity of thinking styles in a cooperative group, CL methodology promotes creative and novel ideas among the students (Kim & Song, 2012). Therefore, a more in-depth analysis of this methodology in the school context is necessary to have a broader view of the possible influence of this variable on the development of creative thinking.

The present study

The present study aimed to longitudinally examine the trajectory of creative thinking in late childhood (between childhood and early adolescence), specifically between 9 to 12 years. We expected to find a significant age-related improvement in creative thinking. In addition, since participants belonged to two different schools that delivered different methodologies (cooperative learning -CL-, and individualistic learning -IL-), we could explore the effect of this variable on creative thinking performance. Therefore, we predicted that the CL students would show significantly greater improvement than the IL group between Test 1 (T^1) and Test 2 (T^2).

Methods

Participants

Fifty-three students (23 boys and 30 girls) from two different elementary schools in the urban area of the province of Almería (Spain) were recruited. The participants were assessed twice: T^1, at the beginning of the 5th grade (November) of Primary School (*m*= 9.81 years; *Sd* = .48); T^2, and at the end of 6th grade (June) (*m*= 11.35 years; *Sd*= .52). The participants were students from Spanish (*n*= 20) or migrant families (Morocco, Romania, Portugal, and Sub-Saharan countries) who were born in Spain or schooled at early ages in the Spanish educational system (*n*= 33; 60.38%). All participants showed acceptable competence in the Spanish language according to the school curriculum demands.

It should be noted that the students of this study were included as a part of a broader developmental investigation to examine the changes in cognitive processes across late childhood.

The two participating schools were selected due to their similarities in demographic characteristics and the different teaching methodologies experienced, that is, Cooperative Learning in one school, and Individualistic learning in the other. Therefore, two separate groups were distinguished according to these schools (Table 1). The teachers involved were interviewed to gather information on both methodologies (Table 2). Moreover, teachers reported information regarding their training. Cooperative learning teachers (two teachers) attended face-to-face and online training sessions (Teacher training center of Consejería de

Educación y Deporte of Andalucía). This training was focused on theoretical foundations, Cooperative Learning management (implementation sequence), cooperative techniques and lessons, and planning and evaluation through Cooperative Learning. As a result, teachers obtained a certificate of attendance and attainment. No information about the training was reported by the Individualistic learning teachers (two teachers).

Table 1

Socio-demographic characteristics of Cooperative and Individualistic Learning groups.

		CL (n= 25)	IL (n= 28)	*Statistic*	p
Age	T^1	9.84 (Sd= .47)	9.78 (Sd= .49)	t = 1.48	.148
	T^2	11.44 (Sd= .51)	11.28 (Sd= .53)	t = 1.58	.123
Gender				X^2= .007	.933
	Girls	14	16		
	Boys	11	12		
Ethnic Background				X^2= 1.91	.136
Spanish		8	12		
Migrant families		17	16		

Note: CL= Cooperative Learning ; IL= Individual Learning

Table 2.

The main characteristics of CL and IL methodology.

Methodology	Cooperative	Individualistic
Interaction	Mix-ability groups of 3-4 members. Face-to-face interaction. Individual effort depends on group commitment and social motivation.	Students are seated individually. The student did not share any materials and activities with a classmate. Individual effort depends on one's own motivation and external rewards.
Goals	Established by consensus between the members of the cooperative groups. Dependent on workgroups. The group should work together until all group members have understood and completed the activities successfully.	Achieved individually and not agreed upon. Dependent on one's own abilities and skills.
Teacher role	Students see the teacher's role as a guide and adviser. Use of specific cooperative routines (e.g., jigsaw)	The teacher is the principal evaluator. Teachers reported no specific strategies. Teaching based on an expository approach. They explain and share a reading, and then, students are involved in various individual activities.
Evaluation	The achievements are assessed by final group projects, portfolio (individual and group), investigative activities and both closed and open-ended activities.	The achievements are assessed by exams, final tests, and closed-answer activities. The achievements are measured through the knowledge acquired.

	Achievements are measured through personal skills and knowledge, including the students' social, emotional, and affective competencies. Various ways of evaluation are applied, including the teacher and the students themselves (Self- and co-evaluation*).	

*Cooperative group evaluation.

Note. In the cooperative learning group, the cooperative methodology was conducted in subjects such as Spanish language and literature, Mathematics and Arts by the same teacher; while the rest of the subjects (Natural and social sciences, Physical Education and second language) were delivered by different teachers using an individualistic methodology. For example, in the Spanish educational system, a principal teacher delivers basic subjects (Spanish language and literature, mathematics, and arts). In contrast, specific teachers deliver other subjects such as natural and social sciences, Physical Education, and Second languages. Moreover, the individualistic group followed the same teacher allocation concerning the subjects, although all were delivered using the same methodological structure: individualistic learning.

Procedure

At both T^1 and T^2, students from each group (CL and IL) completed the CREA Test in their usual classroom. All participants received the instructions at the same time. These specific instructions were given as indicated by the authors of the test manual (Corbalán et al., 2015). In addition, each participant was given an individual answer sheet and the corresponding slide image. For impartiality reasons, the study used the same evaluator for each group. Therefore, the two groups (CL and IL) were evaluated with a 24-hour time difference due to their locations. Finally, two external and impartial (Double-blind) assistants participated in correcting the test.

The procedure of this study followed the Spanish personal data protection law of the $5^{th\ of}$ December 3/2018, with the Ethical Principles for Medical Research Involving Humans of the World Medical Association's Declaration of Helsinki. Furthermore, the study was was approved by the research ethics board of the University of (__) and by the Provincial Authority of Education of the Autonomous Community of Andalucía government.

Measures

CREA Test. Divergent thinking tests allow us to obtain a cognitive measure of creative thinking (Corbalán et al., 2015). This test allows for completing the greatest possible number of questions in 4 minutes.º These questions are based on a slide image (given at the beginning of the test) in paper format and an answer sheet. The image is black, which is presented on a yellow background. We used two different slide images suitable for children between the 5^{th} and 6^{th} grades of Primary School for T^1 (Image ‘A’) and T^2 (Image 'C'). Image 'A' shows an older telephone, while Image 'C' shows a waiter and a customer in a confusing scene in a restaurant. All the questions are accounted for except decontextualized and repeated questions and "repertory" questions without justification such as "What? "When?" or similar. One point is given for an appropriate response and an extra point is awarded when the participant combines syntactically independent schemes (which are considered by the author as a cognitive scheme) such as the use of compound questions (e.g., “Is the handle used to charge the phone, or as a prize machine?”). A single score is obtained from the total number of valid responses (questions). The CREA test shows strong reliability, convergent validity with Guilford's divergent thinking tasks, and discriminant validity with aptitude and intelligence measures (OTIS Sencillo, Test Elemental de Inteligencia -TEI- and Test de Aptitudes Escolares -TEA-2-**)** in children and adults (Corbalán et al., 2015).

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) v. 23.0 (IBM Corporation, Armonk, NY, USA). Kolmogorov-Smirnov test (with Lilliefors correction) was conducted to determine whether the study variables showed a normal distribution. To detect possible differences by gender or ethnic background in creative thinking, we used student's t-tests for each testing. To identify the possible effect of time and teaching methodology on creative thinking, we conducted a 2 (CL, IL group) x 2 (T^1, T^2) repeated-measures analysis of variance (ANOVA) of the CREA test scores. Post hoc comparisons were made using Sidak's test. Statistical significance was set at $p \leq 0.05$. *Partial Eta-Square* (η^2_p) and *Cohen’s d* were reported as measures of effect size. Conventional level for *Partial Eta-Squared* was $\eta^2_p > .01$ as a small effect, $\eta^2_p > .06$ as a medium effect, and $\eta^2_p >$

.14 as a large effect (Cohen, 1973). About *Cohen's d* the level was: trivial (<0.2), small (0.2-0.49), medium (0.5-0.79), and large (≥0.8) (Cohen, 1988).

Results

First, we tested possible differences by gender or ethnic background in CREA scores. No statistically significant differences by gender were found at T^1 (t= -.23; p= .82) or T^2 (t= .08; p= .93), as well as by ethnic background at T^1 (t= .35; p= .73) or T^2 (t= -.97; p= .34) (data not shown).

We carried out a 2 (CL group, IL group) x 2 (T^1, T^2) repeated-measures ANOVA of the CREA scores, which revealed that this interaction was significant ($F_{1, 51}$= 9.27; p= .004; η^2_p= .15; Figure 1). *Post-hoc* analysis indicated that both the CL (p< .001) and IL (p< .05) groups showed significant improvement in creative thinking between T^1 and T^2. At T^1, the CL (m= 6.84; *Sd*= .768) and IL groups (m= 8.39; p= .726) were statistically similar in creative thinking (p= .148). However, at T^2, the differences on creative thinking perform between CL group (m= 13.64; p= .975) and the IL group (m= 10.571; *Sd*= .922) were statistically significant (p= .026). The improvement index (obtained by subtracting T^1 from T^2) showed that 92% of students in the CL group improved their performance (the remaining 8% corresponded to 2 students). In comparison, 64 % of students from the IL group showed an improvement (the remaining 36% corresponded to 10 students).

In addition, the ANOVA yielded a significant main effect of time ($F_{1, 51}$= 34.98; p< .001; η^2_p= .41) on creative thinking performance. *Post-hoc* analysis showed a significant general increase between T^1 (m= 7.62; *Sd*= .528) and T^2 (m= 12.11; *Sd*= .671) (p< .001). The main effect of methodology group was not statistically significant ($F_{1, 51}$= .651; p= .424.; η^2_p= .01).

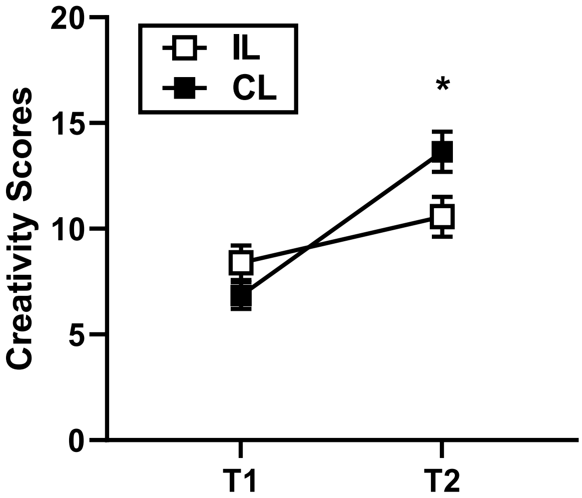

Figure 1. *Differences in creative thinking between T¹ and T² and teaching methodology groups (CL=Cooperative Learning; IL= Individualistic Learning). Asterisk indicates statistically significant differences between CL and IL in T² (* p < .05)*

Discussion

This study set out to analyze the trajectory of creative thinking across late childhood, a transitory stage between childhood and early adolescence (9 to 12 years old) measured by the CREA Test (Corbalán et al., 2015). For this purpose, two tests (T¹ and T²) were administered to children between the fifth (T¹) and sixth (T²) grade of Primary School. Our findings confirmed our hypothesis, which predicted a significant age-related improvement in creative thinking between the two tests, thus indicating a general improvement in creative thinking across time. These results agree with those of previous studies, suggesting that creative thinking performance increases from 9-11 years old (Gralewski et al. 2016; Smith et al., 1983; Torrance, 1968). The latter authors suggested that a learning experience is a creative act of constructing knowledge and adaptation that could undergo critical changes throughout creative thinking development. Creative thinking changes due to interacting with the environment and others along with objects in a particular setting. Therefore, the school environment is an important socio-cultural context that could mediate between individual and social dimensions and is thus a space where creativity is expected to emerge (to a greater or lesser degree) and be supported (Maksic & Smiljana, 2021).

Moreover, creative thinking is a skill that allows children to generate original and novel ideas (Lara, 2013). In this sense, creative thinking is a cognitive process whose development could be linked to neuropsychological changes in this stage of life. Studies in this field have concluded that a direct positive correlation exists between creative thinking and neuropsychological maturity (Ramírez et al., 2017).

Moreover, these striking findings suggest that the extent to which creative thinking develops could be conditioned by the teaching methodology (Henriksen et al., 2021). We recruited participants from two schools that adopted different methodologies: cooperative learning (CL) and individualistic learning (IL). We observed that the scores of the CL students increased significantly more than those of the IL group between Test 1 (T^1) and Test 2 (T^2). These findings are supported by previous studies, which suggest that creative thinking is developed across late childhood, particularly in those students who have received specific methodology or training (Doron, 2017; Gu et al., 2019). In our study, no specific activity programs were implemented in either group, which means that all activities were designed by the teacher according to the contents and objectives of the curricula framework and were adapted to the methodology (Cooperative or individualistic) applied for each group. According to the teachers involved in our study, these organizational differences between groups were based on the student interactions and the teacher.

On the one hand, CL — unlike IL — encourages students to work together in small heterogeneous and mixed ability groups. CL strategies consider the students' interactions from a position of respect for each individual's abilities, needs, and learning styles. In IL, each student works individually towards achieving the proposed goals, which can lead to competitive attitudes. On the other hand, the CL teacher acts as a facilitator of interactions, promoting and supervising group self-management strategies and providing the students with the basic resources and tools required to achieve their objectives. In contrast, the IL teacher unilaterally guides the learning and, usually, directs the specific planning needed to achieve the objectives (e.g., activities, exams, extra activities). At the same time, CL students agree on all the steps and plans required to achieve the objectives. According to Hertz-Lazarowitz and Shachar (1990), the CL teacher's attitude tends to be more caring, positive, and effective, and the language more spontaneous, varied, and creative.

In contrast, it has been argued that IL teachers are usually more authoritarian, rigid, and less friendly. Previous studies suggest that these distinguishing characteristics of the two methodologies (CL and IL) could be decisive in student performance (Gillies, 2014). For example, Johnson and Johnson (2002), in a meta-analysis of 111 studies, found that CL (compared to IL) had the strongest effects on a wide range of skills involved in the learning process as well as achievement, socialization, motivation, and personal self-development.

The present study extends previous research analyzing how the CL approach can enhance creative thinking in different educational stages by comparing the CL and IL approaches (Catarino et al., 2019; Marashi & Khatami, 2017; Siew & Chin, 2009). Moreover, our results are aligned with previous studies in which CL and IL groups were compared. In a study conducted with Sixty fifth-grade students, Segundo et al. (2020) found a significant increase in creativity scores in the CL group compared with the IL group across time. Furthermore, the CL group showed a significant increase in creative thinking (measured by CREA Test; Corbalán et al., 2003) in two months, while IL students did not show improvements in the same period. In contrast to these previous findings, the elapsed time in the current study was greater (18 months), which has allowed us to observe longer-term changes. Therefore, an increase in divergent thinking test performance was observed across time in both CL and IL groups. However, the CL group showed significantly greater performance gains than the IL group between the tests (and the CL group showed a higher score than the IL group on T^2). Thus, our hypothesis is confirmed, meaning that creative thinking can be significantly improved by applying CL methodology in school-age children.

Our study highlights the potential improvements in performance on a creative thinking task across late childhood., while also showing how classroom methodologies could affect such development. However, our study may have some limitations. First, we used a divergent thinking verbal test (CREA) for creative thinking assessment. This test is based on the principle that creative thinking comes from the individual capacity to develop questions considered the product of a cognitive system related to problem finding (Corbalán et al., 2015). Basadur et al. (2000) suggest that problem finding is a creative process for entertaining new hypotheses, considering discrepancies, and facing contradictory situations. This is an interesting and novel measure for creative thinking. Moreover, the test shows strong reliability and concurrent validity with Guilford's divergent thinking tasks and discriminant validity according to other aptitude and intelligence measures. However, the CREA Test is focused exclusively on the verbal domain, which could be a limitation to understanding the individual creative thinking processes since the CREA test requires specific skills and linguistic competencies not controlled for in this study. Thus, for future studies, several possibilities could be considered.

First, there is a need for greater control of other factors (e.g., language development, abstract reasoning, or academic achievement) which could help to understand the nature of creative thinking and the involvement of these variables in the learning processes and, consequently, in the development of creative thinking. Second, it would be useful to employ a measure of creative thinking that allows for testing other domains such as visual and figural tasks, and different components of creative thinking such as fluency, elaboration, originality, and flexibility.

No differences according to gender or ethnicity were found for the measures of interest in this study. However, greater control of language competence could be an important issue for this study since 60 % of our participants belong to migrant families. Although the students from migrant families showed adequate competence in the Spanish language (under curricula standards), we did not control for factors such as varying degrees of bilingualism or exposure to the mother tongue. Earlier studies found a correlation between creative thinking and different levels of linguistic competence. For example, Sampedro and Peña (2019) divided a sample of children (9-12 years old) into three groups depending on their level of bilingualism (low, medium, and high). The authors found that a high level of bilingualism was linked to better performance on verbal and figural creativity tasks. Moreover, a low level of bilingualism was related to higher scores in creative verbal thinking. Therefore, an exhaustive analysis of the linguistic characteristics of the participants could help to obtain a more in-depth understanding of our findings.

Finally, our study faithfully represents the integral nature of the groups within the school environment. In other words, in no case were the students chosen from different classrooms (e.g., randomly) and thus the classroom ecologies were strictly respected. For future research, we emphasize the importance of respecting these aspects, which are intrinsically linked to the processes of learning and development. Nonetheless, the fifty-three students involved in this study may not represent the entire population of Spanish primary school children. A larger sample would provide a more representative view of the trajectory of creative thinking and the effects of classroom methodologies on such development.

In conclusion, the present findings indicate the importance of teaching methodologies — particularly CI — in developing creative thinking. These results suggest that cooperative learning could be a powerful mediating factor in the development of creative thinking, which has a significant impact on both the learning process and the integral development of the child. Our study helps to understand, at least in part, the nature of creative thinking development and provides new evidence to inform educational strategies that could be used to promote creative thinking processes in the school environment. In short, this study brings to light the important role played by the classroom in the learning experiences by which students build and develop their socio-emotional and cognitive abilities and creative thinking skills.

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E4

Creative thinking skills and executive functions in preadolescent children

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Creativity research journal (Presentado)

Abstract

Creative thinking is understood as individual cognitive and meta-cognitive processes that generate innovative and adaptive ideas. Although studies have suggested that executive functions (EFs) play an important role in creative thinking, this association is unclear across later childhood. Based on a comparative (high and low) clustering analysis of creative thinking performance (PIC-N test), this study aimed to identify individual differences in EFs *cool* (Working-Memory -WM-, Cognitive Flexibility, Inhibitory Control, and Planning) in a group of 60 preadolescents (children from 6th-grade primary school), whose were selected from two Spanish schools with different methodological approaches (Cooperative and Individualistic learning). The results revealed that high creative thinking scores were associated with better performance on WM and Cognitive Flexibility tasks. Our findings are supported by previous studies which suggest a relationship between EFs and creative thinking, and we consider possible influences of cooperative learning as a contextual factor.

Keywords*:* Creative thinking, executive functions, late childhood

Introduction

The relationship between creative thinking and Executive Functions (EFs) has attracted much attention from researchers and educators in recent years. EFs refer to a multidimensional construct that includes a set of cognitive abilities such as managing information, self-regulating, adopting reflexive and non-impulsive behavior, and adapting behaviors to the demands of the current context (Diamond, 2013). EFs are involved in individual learning processes and participative, active, and reflective attitudes to perform complex tasks toward an objective or accomplishment (Marcovitch et al., 2008). Late childhood appears to be a critical period of changes in these cognitive processes, associated with neural network developments (Anderson, 2002; Zelazo & Carlson, 2012). Moreover, these changes in the child's neurocognitive development are linked to other processes such as creative thinking (Ramírez et al., 2017).

Creative thinking is a construct necessary to learn and integrate new knowledge and generate original and novel ideas. In addition, a creative mind is necessary to develop coping and adaptive skills (Behnamnia et al., 2020; Wang, 2012). Empirical evidence shows that EFs play an important role in creative thinking (Gilhooly et al., 2007; Nusbaum & Silvia, 2011), which has prompted new research aimed at examining the relationship between these constructs. However, studies conducted in the child population are scarce. Therefore, the present study aims to observe the relationship between creative thinking and EFs in 12 year-old children.

Creative thinking and executive functions

Creative thinking is a cognitive process used to generate effective (new and original) ideas and alternatives for solving tasks. Creative thinking allows people to understand, invent, and establish new and personal connections between what they know and learn. Thus, creative thinking is understood as a process by which individuals configure their knowledge in a meaningful way (Lara, 2013; Torrance, 1972). According to Osborn

(1953), creative thinking (e.g., problem-solving strategies) plays an important role in learning. Osborn's model places creative thinking at the core of information processing by suggesting a two-branch model: a) knowledge acquisition (absorb and retain information); and b) knowledge application (creativity and judgment). The main characteristic of Osborn's model is related to the ability to create and transform representations based on past observations and significantly transcend them through generating creative representations (Dziedziewicz & Karwowski, 2015). Thus, creative thinking is a part of the equation in which knowledge and evaluation are combined, resulting in an innovative product (Parnes, 1977). In other words, creative products are the result of applying previous knowledge to create new ideas, applying an evaluative process to select the one that is most appropriate (Basadur, 2005). Therefore, creative thinking enables students to connect and link their prior knowledge and new ideas. Teachers in school involve students in the learning experiences (for instance, through classroom methodology and learning strategies) to connect the children's background with the academic subject matter. Therefore, creative thinking plays an important role in learning since it connects students' previous experiences and knowledge to new understandings and possibilities (Beghetto & Schuh, 2020).

A process strongly associated with creative thinking is divergent thinking, which refers to generating logical alternatives using existing information. Divergent thinking task performance is considered a strong predictor of real-life creative behaviors in various domains (Barbot & Said-Metwaly, 2020; Hong et al., 1995). Based on this notion, creative thinking potential has been traditionally measured through four basic components of divergent thinking: Fluency, Flexibility, Originality, and Elaboration (Guilford, 1967; Torrance, 1972). Fluency refers to developing multiple responses or solutions to a certain stimulus; flexibility is related to changing perspective and adapting ideas to new rules; originality is the capacity to generate uncommon or unusual responses, unexpected ideas; and elaboration is the capacity to add details to an existing idea or object (Handayani et al., 2021). These components can be visible within the school context through activities designed within the curricular framework. Some authors have suggested the use of classroom activities that include brainstorming (about a subject), alternative responses (creating an ending for a story), elaboration of more complex ideas (adding complements to a picture or a narrative), or developing products composed of different elements (collages based on a song) (Shively, 2011). These activities should include exploring a wide range of materials, self-discovery of theories, hypotheses, or/and problems to solve, forming work-groups to discuss opinions and share knowledge, and open-ended projects that must be completed using problem-solving activities (Handayani et al., 2021).

From a traditional school perspective, a look at creative behavior could involve exploring irrelevant ideas, perceptions, and interpretations (Beghetto et al., 2020). However, the educational approach of creative thinking could potentially benefit students. What may seem at first like a potentially negative distraction, a suitable educational creative environment could construct new, personally meaningful insights and understandings (Baird et al., 2012). Furthermore, creative outcomes emerge from the continuous effort of going beyond current knowledge by using the imagination (i.e., exploration) to adapt to the progressively changing requirements of the context (Bereiter & Scardamalia, 2021). Thus, the reciprocal knowledge-creation relationship makes learning a problem-solving process in itself. From this perspective, the link between learning and creative thinking is clear. Indeed, previous studies have suggested that creative thinking is an implicit factor in the learning process which, moreover, can be learned and developed through specific educational strategies (Burnard, 2006; Odena & Welch, 2009; Segundo et al., 2020; Vedenpää, & Lonka, 2014).

Creative thinking has an important role in individual development. Consequently, educational research has attempted to identify the key factors involved in creative skills in children, as well as the environment, teaching methodologies, and cultural/socioeconomic contexts or cognitive processes (Davies et al., 2013; Segundo et al., 2020; Reiter-Palmon, Herman & Yammarino, 2008). Creative thinking represents complex mental activities of the generation of ideas and solutions. This has raised the question of what cognitive processes are involved in creative thinking. In this sense, cognitive and neuroscience studies have established that EFs play an important role in this complex construct (Krumm et al., 2018; Yetti et al., 2019).

EFs are the basis of human information processing. They comprise many higher-order cognitive processes that guide thoughts and actions toward a goal, control behaviours, and allow individuals to adapt to novel and complex situations (Diamond, 2013). Empirical studies on how EFs are organized have suggested that the taxonomy of executive functioning consists of three basic components of EFs (Miyake et al., 2000): working memory (WM), inhibitory control, and cognitive flexibility. Although there are some differences in their developmental trajectories, these three EFs *cool* appear to operate in an interactive manner (Best & Miller, 2010).

WM is responsible for actively encoding, maintaining, and updating information over a short time (Diamond, 2013). This component allows for managing information and transforming it into thoughts and actions and consequently supports essential processes such as language or mathematical reasoning (Magimairaj, 2018; Peng et al., 2016). Cognitive flexibility represents the ability to switch between multiple tasks, operations, or mental sets, allowing efficient focus on changes in environmental demand and adapting behaviors to new situations. Cognitive flexibility has been linked to problem-solving, arithmetic, and language skills (Bull & Scerif, 2001; Hooper et al., 2002). Finally, inhibitory control refers to the control procedure whereby the individual deliberately suppresses (a) prepotent responses, or (b) distractor interference (Friedman & Miyake, 2004). These three core EFs *cool* are involved in developing more complex processes such as planning, reasoning, or problem-solving (Diamond, 2013).

The studies investigating the relationship between WM and creative thinking have been scarce, particularly in childhood. However, research conducted with adult samples has provided evidence of the positive contribution of WM to divergent thinking (Benedek et al., 2014; De Dreu et al., 2012; Süß et al., 2002; Zabelina et al., 2019). According to these studies, WM is an important cognitive component in the performance of divergent thinking tests since it contributes to information management by helping to connect existing knowledge with new ideas and thoughts (i.e., generating, contrasting, and selecting ideas) to provide an adequate and contextualized response (Lee & Therriault, 2013).

The association between cognitive flexibility and creative thinking is widely accepted (Chi, 1997). Individuals require flexible shifting between mental sets to generate novel ideas (e.g., new mental categories; Hennessey & Amabile, 2010). Some divergent thinking measures score flexibility according to the individual's capacity to describe different semantic categories during idea generation (e.g., Torrance, 1972). However, there is insufficient evidence to believe that divergent and creative thinking (as well as its components) could be predicted by performance on switching tasks, which could depend on the type of task performed. Pan & Yu (2016) measured the creative thinking of young adults through three divergent thinking tests (both verbal and figurative), and measured cognitive flexibility by three shifting tasks (verbal and figure-based tasks). Their results showed associations between creative thinking and cognitive flexibility. However, an adult-sample study conducted by Benedek et al. (2014) showed no association between creative thinking (measured by the individual capacity for generating as many ideas as possible in different categories) and shifting (assessed by the number-letter task). There is, however, a lack of empirical research providing evidence on the relationship between cognitive flexibility and creative thinking in children.

The association between creative thinking and inhibition seems unclear. For example, Benedek et al. (2012) found that fluency ideas (ability to produce responses to a given stimulus) as a component of creative thinking was promoted by inhibitory control, measured by an individual's capacity to inhibit prepotent responses. On the other hand, Groborz and Necka (2003) studied the association between cognitive control assessed by the Stroop and Navon tasks (both tasks require the inhibition of interference effects of incongruent stimuli) and creative thinking, assessed by various pictorial tasks. Their findings revealed relationships between creative performance and high cognitive control. However, other studies have reported no association between these constructs (Burch et al., 2006; Green & Williams, 1999; Stavridou & Furnham, 1996), and some have even found a negative correlation, associating low levels of inhibitory control with high levels of creative thinking (Carson et al., 2003; Radel et al., 2015).

Planning skills are defined as the capacity to organize behaviors to generate and structure sequences of responses. This high-order function, which emerges from the three core components (WM, cognitive flexibility, and inhibition control), enables children to adapt sequences of actions in time and space toward a goal that requires a series of intermediate steps (Diamond, 2016). Adequate planning skills allow for the flexible and adaptive behaviors necessary for cognitive skills such as problem-solving or reasoning (Diamond, 2013). Unfortunately, studies conducted with children on the relationship between creative thinking and planning skills are scarce. Therefore the conclusions are unclear and even contradictory.

Empirical studies have linked better planning skills with superior performance on creative thinking tests (e.g., divergent thinking and solving-problem tests; see Marta et al., 2005; Osburn & Mumford, 2006). However, in a study conducted in middle childhood, Maureira (2018) reported no relationship between the two constructs. However, Krumm et al. (2020) compared two groups of children based on their creative thinking performance (High and Low creative thinking performance) and found better executive performance (e.g., WM and cognitive flexibility) in children with higher creative thinking performance (but no differences in planning skills).

Purpose of the Present Study

The purpose of this study was to transversally examine the relationship between EFs *cool* (WM, cognitive flexibility, inhibition control, and planning) and creative thinking in 12- year-olds, a transition period between late childhood and early adolescence. Our main hypothesis was that there would be a relationship between creative thinking and EFs *cool*. Therefore, we anticipated that children with better performance on the creative thinking task would also obtain better scores on the cognitive tasks of WM, cognitive flexibility, inhibitory control, and planning. Furthermore, the children (6th-grade primary school) were recruited from two schools employing different methodological approaches to learning: Cooperative and Individualistic learning. Therefore, we considered this to be a contextual factor that could mediate the relationship between creative thinking and EF task performance.

Method

Participants

The sample consisted of 60 pupils (25 boys and 35 girls) from two different elementary schools in the same urban area of the province of Almería (Spain). The mean age of the participants was 11.92 (*Sd*= .37), and they were assessed at the end of the 6th grade (June) of Primary Education. The participants were Spanish speakers (*n*= 23) or Spanish speakers from migrant families (*n*= 37; 61.6%). All children, including those from migrant families (Morocco, Romania, Portugal, and Sub-Saharan countries), were born in Spain or schooled in the Spanish educational system at early ages and had a suitable competence in the Spanish language according to the requirements of the school curriculum.

The children of this study were participants of a larger research project in which we longitudinally assessed their development in EFs and creative thinking across late childhood (9 to 12 years old). Moreover, due to the fact that the children were recruited from schools with different classroom methodologies (Cooperative and individual learning), methodology was analyzed as a contextual factor in EFs and creative thinking development. These methodologies are described in more detail in previous studies (see Segundo et al., in press).

Procedure

The students completed all the computerized tasks individually during normal school hours in a separate classroom provided by the school managers. The length of each session for the computerized tasks was one hour. In addition, the creative thinking test was administered collectively in a classroom session that lasted approximately 40 minutes. Two trained research assistants conducted the assessments, while two external double-blind evaluators participated in correcting the test.

All personal information was treated in accordance with the Spanish personal data protection law of the 5th December 3/2018. The cognitive tasks were designed and managed on a personal computer using E-prime v.2.0 (Psychological Software Tools, Pittsburgh, PA). Informed consent was obtained from the parents in accord with the Ethical Principles for Medical Research Involving Humans of the World Medical Association's Declaration of Helsinki. All procedures in this study were approved by the research ethics board of the University (...) and by the Provincial Authority of Education of the Autonomous Community of Andalucía government.

Measures

Creative thinking task

PIC-N (Creativity Imagination Test for children; Artola et al., 2010) was designed to assess creative thinking using children's capacity to use their imagination. PIC-N assesses creative thinking through four games or sub-tests, which assess partial variables (or components) of divergent and creative thinking: Fluency, flexibility, originality, and elaboration. Moreover, the test assesses the use of shading and colors, titles, and unique details as elements of creative graphic expression. The first three games or tasks assess the narrative dimension according to fluency, flexibility, and originality. Thus, creative thinking is assessed by the ability to generate a) multiple responses based on certain information (fluency), b) variety of ideas or categories (flexibility), and c) unusual ideas (original).

Game 1 (10') asks participants to write down what could be happening in a scene shown in a drawing. These game scores are obtained from two components: *Flexibility* categories that individuals can generate. For instance, physical actions (directly or indirectly related with an object in the drawing): "The boy is stealing treasure"; references to time and places: "The boy is on an island" (assigned 1 point for each given category). *Fluency* is measured by the global number of responses (1 point each). ***Game 2*** (7') asks participants to suggest as many uses as possible for an object (Rubber tube). These game scores are obtained from three components: *Flexibility*, categories (uses of the rubber tube) that individuals can generate: as a play, for sports, scholar use, etc. (1 point is assigned for each given category). *Fluency* is measured through the global number of responses (1 point each). *Originality* is scored by multiplying the frequency of each category (number of responses in each category) by a coefficient. A higher coefficient indicates a more original response. For instance, the coefficient for the play category (e.g., jumping) is 0 (given its truism), while the coefficient for the giving the use of communication (e.g., telephone) is 3 (less obvious).

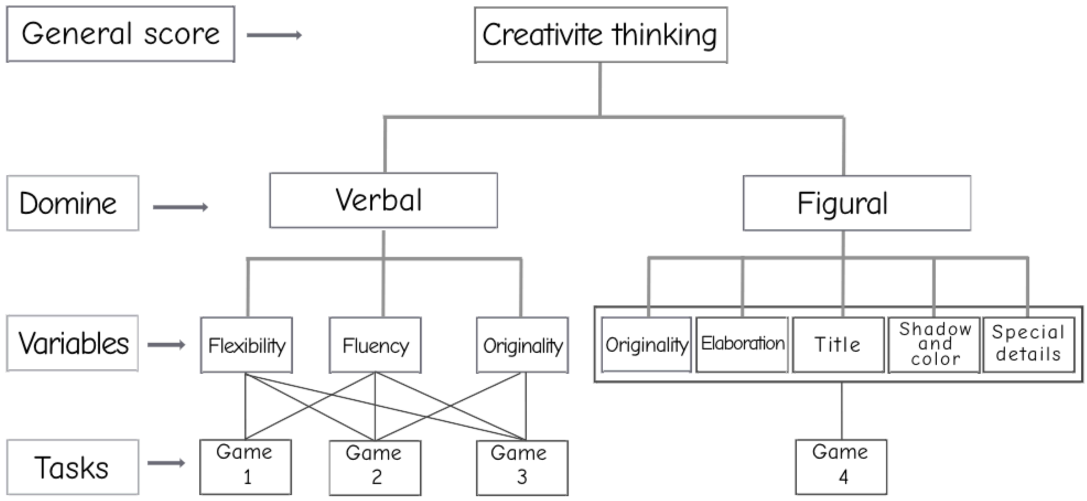
Game 3 (10') Asks the participant: *What would happen if the squirrels became dinosaurs?* Participants have to write down as many situations as possible. These game scores are obtained from three components. *Flexibility*, includes categories (situations given about the task) that individuals can generate, reaction (e.g., scared, amazed), and coexistence (between humans and dinosaurs), (1 point is assigned for each given category). *Fluency* is measured through the global number of responses (1 point each). Similarly, originality is scored by multiplying the frequency of each category (number of responses in each category) by a coefficient. A higher coefficient indicates a more original response. For an obvious category (e.g., convivence, where the student sees a friendship between humans and dinosaurs), the coefficient is 0. In contrast, the coefficient for a fanciful category (e.g., dinosaurs would have satellites to connect with other galaxies) is 3 (less obvious). The score for each component in each game is summed, thus obtaining a score for narrative fluency, narrative flexibility, and narrative originality. The sum of all these components is the narrative creative thinking score.

Finally, in ***Game 4*** (10'), the participants must complete four unfinished drawings and write a title for each one. A graphic dimension is scored according to originality, elaboration, shading and colors, titles, and unique details. These components are scored on a scale from 0 to 3 depending on the singularity of the response (*originality),* the number of details (*elaboration*), creative use of these elements (*colors and shades*), use of resources as metaphor, and expanding ideas (*title*), and others significant details (*unique details*). The score on component in the drawing is summed to produce a score for visual creative thinking.

A general creative thinking score is obtained by summing the scores of the narrative and graphic creative thinking dimensions (Figure 1). The authors reported a Cronbach's alpha of 0.83 for the chosen sample (n= 508) and adequate internal reliability.

Figure 1

Theoretical factorial structure of PIC-N (Artola, et al., 2010).



Executive Function Tasks

This study included five EFs *cool* tasks: 1) *Sternberg-type task,* which assesses the encoding and maintenance of information in working memory (WM); 2) *2-back task*, which evaluates key processes such as monitoring, updating, and manipulation of remembered information in the WM; 3) *Child Attention Network Test* -ANT- which evaluates the efficiency to suppress distracting information (interference control) while selectively attend to others stimulus targets; 4) *Number-Letter task* measuring individual cognitive flexibility; and 5) *Tower of Hanoi,* which evaluates planning processes involved in the preparation and development of sequences of actions to achieve a specific goal. These tests have been described extensively in Segundo et al. (in press).

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) v. 23.0 (IBM Corporation, Armonk, NY, USA). Kolmogorov-Smirnov test (with Lilliefors correction) was conducted to determine whether the study variables showed a normal distribution. We classified subjects according to their PIC-N scores through a hierarchical (Ward's) clustering method, as recommended by current theoretical trends (Hair et al., 2010). A *Student's t-test* for two independent samples was conducted to determine differences in WM (2-Back and *Sternberg task)*, cognitive flexibility (Number-Letter task), inhibition control (ANT), and planning (Tower of Hanoi) between the groups (High and Low creative thinking). A Pearson's Chi-squared test was used to analyze the associations among the qualitative variables. Differences were considered statistically significant for values of $p < 0.05$, and a trend towards significance was defined as $p \leq 0.08$.

Results

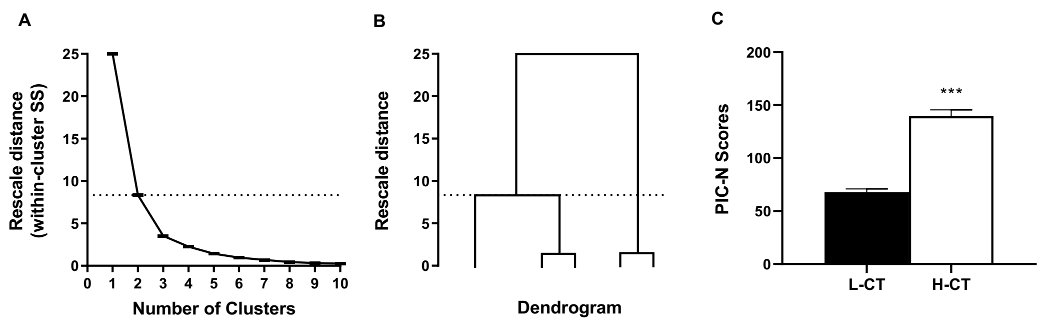
Creative thinking performance

The mean PIC-N scores of the participants was 103.68 (*Sd*= 44.36). *Student's t-test* did not reveal differences in PIC-N scores ($t_{58} = .237$; $p = .814$) between girls (*m*= 100.91; *Sd*= 42.83) and boys (*m*= 107.56; *Sd*= 47.04).

For this study, participants were divided according to their general scores on the creative thinking test (summed scores for narrative and visual creative thinking). Figure 2A shows the rescale squared Euclidean distance plotted against the number of clusters. The elbow (where the squared Euclidean distance among clusters was smaller) is observed from Cluster 2 onwards. Therefore, the appropriate number of clusters was 2, as seen in the dendrogram (Figure 2B). The cluster showing high creative thinking scores was termed H-CT and represented 30 of the 60 participants (50%). The cluster showing low creative thinking was termed L-CT and represented the other 30 participants (50%). The mean score on the PIC-N test was 139.60 (*Sd*= 32.42) for the H-CT group; and 67.77 (*Sd*= 16.88) for the L-CT group. *Student's t-test* revealed statistically significant differences between group scores ($t_{43,6}$= -10.765; p< 0.001; Figure 2C). We transformed the general score in centile score to compare children with their normative group. H-CT group centile mean score was 82.03 (*Sd*= 10.98); and 32.53 (*Sd*= 16.05) for the L-CT group.

Figure 2.

Clustering analyses according to the PIC-N scores.



Note. (A) Squared Euclidean distance plotted against the number of clusters for the total sample (n= 60) using a hierarchical clustering approach (Ward's criterion). (B) Dendrogram for the application of agglomerative hierarchical clustering. (C) Mean (±SEM) PIC-N scores in High (H-CT) and Low (L-CT) Creative Thinking. Asterisks indicate a statistically significant difference (*** p< 0.001).

No differences in age, gender, or ethnic background were found between the groups. However, we found significant differences between groups regarding the number of participants involved in CL methodology (see statistics in Table 1). These results indicate that the H-CT category comprised 71.4% of the students from the CL group and 31.25% of students from the IL group, while the L-CT category comprised 28.6% of students from the CL group and 68.75% from the IL group (Table 1).

EFs differences regarding creative thinking performance

The analysis showed significant differences between groups regarding EFs *cool* tasks performance. In particular, statistically significant differences were found for the 2-Back task (*d'*; t_{58}= -2.22; *p*= .03; see Figure 3A). The H-CT group (*m*= 1.94; *Sd*= .86) scored higher than the L-CT **(***m*= 1.46; *Sd*= .8**)** group in monitoring, updating, and manipulation of information. Moreover, the differences in the Sternberg task were statistically significant between groups (t_{58}= .247; *p*= .032; see Figure 3B). The H-CT group (*m*= 89.12; *Sd*= 5.87) was significantly better than the L-CT group (*m*= 84.83; *Sd*= 8.95) in coding and maintenance of information in WM. Finally, we observed a tendency toward significance in the percentage of errors on the cognitive flexibility task (Switching cost: t_{58}= -1.96; *p*= .06; Figure 3C). The mean scores indicate that the L-CT group (*m*= 7.33; *Sd*= 14.31) showed a higher cost effect of switching between two tasks or mental sets (which indicates a lower accuracy in the response) than the H-CT group (*m*= 1.97; *Sd*= 4.45). No differences were found for the remaining variables, that is, Inhibitory control (for reaction time: t_{58}= -.038; *p*= .97; and errors: t_{58}= .297; *p*= .767), Planning (t_{58}= .341; *p*= .734) or reaction time of the cognitive flexibility task (Switching cost: t_{58}= 1.45; *p*= .152).

Table 1.

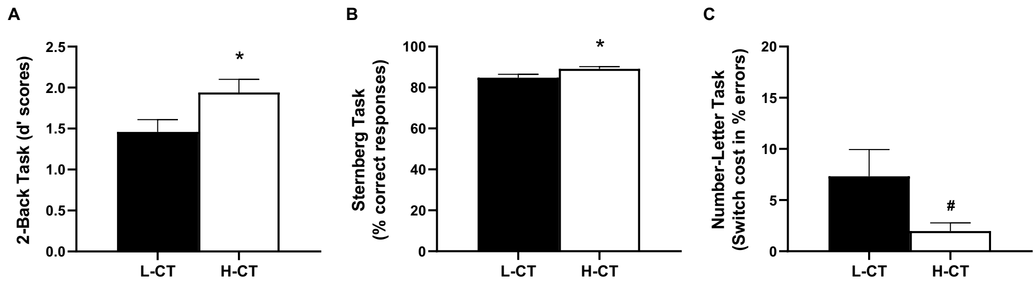
Socio-demographic and educational characteristics of the High (H-CT) and Low (L-CT) creative thinking clusters

		H-CT	L- CT	*Statistic*	*p*
Age		11.92 (*Sd*= .28)	11.9 (*Sd*= .48)	t_{58}= .171	.865
Gender				$X^2(1)$= .07	.793
	Male	13	12		
	Female	17	18		
Ethnic Background				$X^2(1)$= .07	.791
	Spanish	11	12		
	No-Spanish	19	18		
Teaching methodology*				$X^2(1)$= 9.6	**.002**
	Cooperative	20 (71.4%)	8 (28.6%)		
	Individual	10 (31,2%)	22 (68.8%)		

*This is represented by the number and percentage of students belonging to each group

Figure 3

Executive functioning differences between High (H-CT) and Low (L-CT) creative thinking clusters.



Note. (A) Mean (±SEM) d' scores on the 2-Back task (working memory); (B) Mean (±SEM) percentage of correct responses on the Sternberg Task (working memory); (C) Mean (±SEM) of switching cost effect expressed in percentage of errors on the Number-Letter Task (Cognitive flexibility task). Asterisks indicate statistically significant differences (* $p < 0.05$). The number sign indicates a trend toward a significant difference (# $p = 0.06$).

Discussion

The present study aimed to transversally analyze the relationship between EFs *cool* and creative thinking in children in the 6th grade of Primary School. Our first hypothesis predicted a significant relationship between EFs (WM, cognitive flexibility, inhibitory control and planning) and creative thinking performance. To evaluate these relationships, we divided the participants into two groups based on their creative thinking performance (H-CT -High creative thinking- and L-CT -Low creative thinking-), using a creativity imagination test for children (PIC-N; Artola et al., 2010).

Our findings revealed significant differences between groups regarding WM task performance (2-Back Task and Sternberg task). The H-CT group (High creative thinking) scored significantly higher than the L-CT group (Low creative thinking) on both WM tasks. These results are consistent with previous studies suggesting a significant association between high creative thinking and better performance on WM tasks in late childhood (Krumm et al., 2020). Unfortunately, relatively few studies have been carried out with children; however, in adult populations the findings point toward the same conclusions about the association between WM and creative thinking processes such as fluency, elaboration, originality, and flexibility (de Dreu et al., 2012; Süß et al., 2002). According to Benedek et al. (2014), creative ideas emerge from the maintenance and management of information. This implies that creative thinking is a process that requires the monitoring and reviewing of WM content (Updating) by continuously refreshing old information with new and relevant information for current tasks. The creative thinking test used in our study assesses verbal and figurative domains by which the students have to select answers based on a series of requirements.

Regarding verbal tasks, "Game 1" asks the student to generate as many hypotheses as possible when faced with a given scene. "Game 2" asks the student to generate alternative and creative uses for a common object (‘Plastic tube'), while "Game 3" asks them to imagine alternative consequences for a certain situation (" What would happen if the squirrels become dinosaurs?"). These tests or games require the student to generate responses that imply the maintenance of certain "online" rules and the controlled searching and selective retrieval of information in memory. In this sense, the WM seems to participate in identifying and maintaining relevant rules and goals to delimit the information toward the current searching set (Unsworth & Engle, 2007).

This study also examined the implication of cognitive flexibility in creative thinking. Our findings have shown that cognitive flexibility (measured by a switching task) was positively related to creative thinking. Although a tendency toward significance concerning creative thinking was observed, these results support the notion that creative thinking involves cognitive flexibility in late childhood, specifically when measured by shifting tasks (Krumm et al., 2018). The Number-Letter Task assesses the individual's ability to change (Shift) the response criteria between different types of stimuli. There is consensus that creative thinking requires flexibility of thought (Benedek et al., 2104). However, studies conducted on cognitive shifting in adults assessed the quantitative aspects of creative thinking, such as fluency and flexibility rather than qualitative aspects, such as originality (Pan & Yu, 2016). These findings could partially explain our result since the creative thinking test used in this study included several variables and domains including qualitative and quantitative aspects. The general scores come from two basic domains: a) Verbal domain, which includes quantitative variables such as flexibility, fluency, and qualitative such as originality; and b) pictorial domain, which includes only qualitative aspects (note that the task asked students to complete a drawing to assess qualitative aspects such as originality, elaboration, use of shades and colors, or details). We consider that this factor could have a significant effect on the relationships observed.

Our results revealed no differences between the high and low creative thinking groups in terms of inhibitory control, assessed by the Attention Network Test (Flanker task). These observations suggest that creative thinking performance is not related to this aspect of inhibitory control (resistance to distractor interference). Although creative thinkers should seemingly be more able to selectively attend to relevant stimuli while suppress irrelevant stimuli (Eld et al., 2014), previous research has revealed controversial results in this regard. For instance, Rotolo (2016) found no relationship between creative thinking and inhibitory control measured by the flanker-type task; however, an association was found between the creative thinking and N-back task used as a resistance to proactive interference measure (inhibitory ability to suppress memory intrusions). The author suggested that each inhibitory process (resistance to distractor interference and resistance to proactive interference) could be related with different aspect of creative thinking. Capacity of resistance to distractor interference could be a filter during perception which influences on the associative magnitude between ideas or concepts during creative ideation, whereas resistance to proactive interference (inhibition of unoriginal and inappropriate ideas) could allow for more distant associations to be evoked to the WM. Therefore, control could positively and negatively relate to creative thinking, depending on the task to be performed and how these constructs are conceptualized and operationalized. Moreover, most studies have been conducted mainly with the adult population, which means there is a lack of evidence about the relationship between creative thinking and inhibitory control (in all its dimensions) in children.

Some authors suggest that creative thinking requires planning to support new and original ideas (Osburn & Mumford, 2006). However, the lack of studies in this field, particularly with children, makes the conclusions unclear, and our study found no relationship between creative thinking and planning skills. These findings are consistent with previous studies that found no relationship between these two constructs (Marta et al., 2005; Osburn et al., 2006). Moreover, studies with children and adolescents confirm these results. In a study with 10-year-old children, Krum et al. (2020) divided the sample (n = 200) into two groups: High and Low creative thinking. Krumm and colleagues found no relationship between performance on a planning task (Porteus Maze Test) and performance on a creative thinking task (Torrance Tests of Creative Thinking). Students performed equally in the planning task independently of their creative thinking skills. Sánchez-Macías, et al. (2021) also found no link between planning skills (assessed by Tower of Hanoi task) and creative thinking in pre-and adolescent samples. These results could be explained by the types of tasks employed. Presumably, the tasks (both in planning and creative thinking) do not assess common skills. The Tower of Hanoi assesses the individual ability to order and mentally project a sequence of movements to achieve a specific goal. Therefore, this task could be based on the evaluation of convergent thinking, that is, the ability of the participant to find a unique strategy that leads to a unique response as opposed to creating alternative strategies and solutions (e.g., fluency and flexibility). In contrast, the creative thinking task (PIC-N test) requires developing divergent (e.g., divergent thinking) and open ideas, that is, fluency in the generation of ideas (productive spontaneity), the originality in the design of said ideas (unconventional thinking), and flexibility to offer a variety of solutions, both in narrative and figurative tasks.

Moreover, our results have shown a link between creative thinking performance and Cooperative Learning (CL). Three-quarters of CL students were classified as high creative thinkers, while three-quarters of the Individual Learning (IL) group were classified as low creative thinkers. Therefore, our results suggest that students who have been involved in a methodology based on cooperative learning are more likely to show high creative thinking performance. These findings are in line with previous studies that show a relationship between performance on creative thinking tasks and CL (Catarino et al., 2019; Marashi & Khatami, 2017; Segundo et al., 2020; Siew & Chin, 2009). According to these findings, CL strategies involve processes that promote creative thinking (problem-solving strategies and divergent thinking) through exchanging ideas based on the diversity of thinking styles that come together in a cooperative group (Kim & Song, 2012).

Although our findings highlight important relationships between EFs and creative thinking, we should acknowledge some limitations of this work. A potential limitation of this study is the small sample size. A larger sample would allow us to observe more fully the relationships between the variables studied, including the effectiveness of Cooperative learning in promoting creative thinking performance. Furthermore, broader information on socio-demographic characteristics (e.g., home habits, family educational background) would provide a more accurate profile of the students and, thus, bring in possible factors involved in creative thinking. Another limitation could be the alignment between executive tasks and creative thinking assessment. In particular, it is possible that the abilities required for verbal and pictorial tasks are not related. Therefore, a separate score of creative thinking (verbal and pictorial) could provide more information about the relationships between variables. Moreover, EFs tasks with similar characteristics (verbal and pictorial) could provide more comprehensive information on the relationship between creative thinking and EFs, specifically for inhibitory control and planning tasks. However, it is also possible that the assessments do not include the component required for generating creative ideas.

In summary, our research suggests a relationship between EFs *cool* (WM and cognitive flexibility) and creative thinking in preadolescent children. Moreover, our findings indicate the possible influence of teaching methodology on creative thinking task performance. This suggests the need for future research to shed further light on the relationship between the EFs *cool* and various dimensions of creative thinking and the factors that influence these relationships during childhood.

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5

Discusión general

La presente tesis doctoral tuvo como objetivo general estudiar el desarrollo y posible relación entre el pensamiento creativo y las funciones ejecutivas a lo largo del tercer ciclo de Educación Primaria (de los 9 a los 12 años de edad). Además, dada la relevancia de los factores contextuales en el desarrollo de dichos constructos, se analizó las implicaciones del aprendizaje cooperativo como metodología de aula. Para abordar este objetivo general se llevaron a cabo cuatro estudios cuyos principales resultados son discutidos a continuación.

En cuanto al ***primer estudio***, el objetivo principal consistió investigar si el pensamiento creativo (medido a través del test CREA) en niños de 5º curso de Educación Primeria podría ser potenciado a través de un programa estructurado de actividades de lecto-escritura implementado en al aula través de la metodología de aprendizaje cooperativo. Para ello se llevó a cabo un estudio de diseño cuasi-experimental con medidas pre-post- intervención y con un grupo control. Como segundo objetivo se planteó examinar la correlación entre las mejoras del desempeño en la tarea de pensamiento creativo (Test CREA) y el rendimiento académico, medido a través del promedio de calificaciones escolares. Los resultados mostraron que el grupo que participó en el programa de intervención de lecto-escritura basado en el aprendizaje cooperativo, cuya duración fue de dos meses, mejoró significativamente su rendimiento en la tarea de pensamiento creativo. Estos hallazgos son consistentes con investigaciones previas que sugieren que el pensamiento creativo no es un elemento estático, sino una construcción fluida que puede potenciarse a través de programas específicos durante la infancia (Doron, 2017; Gu et al., 2019; Núñez-Gómez et al., 2020). Además, estos resultados son congruentes con los de estudios previos en los que han implantado programas específicos basados en estructuras cooperativas dentro del ámbito curricular (matemáticas, ciencias sociales, lengua, enseñanza de idiomas) han sugerido mejoras en el pensamiento creativo (Catarino et al., 2019; Gillies, 2011, 2014; Hong et al., 2009; Marashi y Khatami, 2017; Siew et al., 2017; Sitorus y

Surya, 2017; Soh, 2017). En su conjunto, los resultados de estos estudios sugieren que las características específicas de estructuras cooperativas, incluyendo el estilo de enseñanza de los docentes (por ejemplo, uso del lenguaje y comunicación específico para el fomento de las habilidades sociales), podría promover la búsqueda de soluciones novedosas en la resolución de problemas, y podría contribuir a la generación de ideas originales (así como al pensamiento crítico y creativo) a través de la motivación y autonomía de los estudiantes, y de la amplia diversidad de estrategias de razonamiento (Hattie, 2009; Kim y Song, 2012; Scott et al., 2004).

En cuanto a las relaciones halladas entre pensamiento creativo y rendimiento académico, los resultados del primer estudio también mostraron una correlación positiva moderada entre las puntuaciones post-intervención obtenidas en el test CREA y las calificaciones medias obtenidas por los niños y niñas en el primer trimestre escolar. Dichos resultados son congruentes con los de otros estudios previos en los que también se han encontrado correlaciones positivas entre ambas variables (Escalante, 2005; Mourgues et al., 2016; Niaz et al., 2000; Wang, 2007; Zhang et al., 2018). No obstante, es importante recordar que la magnitud de la correlación positiva que tradicionalmente se ha observado entre pensamiento creativo y rendimiento académico parece depender del tipo de medidas utilizadas. Así, en el meta-análisis llevado a cabo por Gajda et al. (2017) se observó que las correlaciones positivas entre pensamiento creativo y rendimiento académico eran bajas o moderadas cuando el rendimiento académico es medido a través del promedio de calificaciones (evaluaciones ordinarias de clase) y no a través de pruebas estandarizadas. Según los autores, esto podría deberse a la subjetividad con la que el docente evalúa y califica los conocimientos adquiridos del alumnado; lo que no ocurre en las pruebas estandarizadas. Sin bien, existen una estandarización de la evaluación curricular, en las calificaciones finales podrían incluirse elementos extracurriculares (actitud en clase, comportamiento, realización de actividades complementarias, etc) y que pudieran no estar relacionadas con componentes de pensamiento divergente, como flexibilidad, originalidad, fluidez o elaboración. Es decir, que el docente podría priorizar otro tipo de habilidades (académicas y comportamentales) frente a las habilidades de pensamiento creativo. De hecho, Gajda et al. (2017) sugieren que algunos docentes tienen percepciones negativas hacia los comportamientos o actitudes de los estudiantes que están asociados a la creatividad, y que dicha percepción negativa del docente a dichas actitudes aumenta a medida que avanza la escolaridad. Gajda (2016) señala que, a edades más tempranas (etapa infantil y primer ciclo de educación Primaria), los planes de estudios se centran más en el desarrollo de habilidades y procesos cognitivos respetando la actividad espontánea de los niños; mientras que, a medida que aumentan las exigencias curriculares a lo largo de la etapa de Educación Primaria, el alumnado se enfrenta a requisitos académicos más estrictos que podrían restringir la actividad creativa (exámenes periódicos de conocimientos y pruebas finales, pruebas orales, etc.).

En cuanto al ***segundo estudio***, el objetivo principal fue examinar longitudinalmente el desarrollo de varios componentes de las FFEE *cool* (memoria de Trabajo -MT-, flexibilidad cognitiva, control inhibitorio y planificación) *y hot* (inteligencia emocional y empatía) a lo largo del tercer ciclo de educación Primaria (entre 9 y 12 años). Además, se exploró si la metodología de aula (aprendizaje cooperativo vs individualista) podrían mediar en los posibles cambios de desarrollo observados en esta FFEE *cool* y *hot* durante este periodo. Para la consecución de dicho objetivo se llevaron a cabo dos evaluaciones: Test 1 (T^1), realizada al inicio del *primer trimestre* de 5º grado de Educación Primaria; y Test 2 (T^2), en el *tercer trimestre* de 6º de Educación Primaria. Los resultados confirmaron alguna de las predicciones del estudio, las cuales declaraban una mejora significativa relacionada con la edad en las FFEE *cool* y *hot* a lo largo del período estudiado. Concretamente, con respecto a las FFEE *cool*, los resultados mostraron mejoras significativas relacionadas con la edad en MT (tarea 2-back y Sternberg), en flexibilidad cognitiva (tarea Número-Letra) y planificación (tarea Torre de Hanoi), mientras que no se encontraron mejoras en el control inhibitorio (medido a través del efecto de interferencia de flancos en el *Attention Network Test*).

Con respecto a la MT, los resultados son congruentes con estudios previos que sugieren cambios significativos en el desempeño de tareas de la MT al final de la etapa escolar (Conklin et al., 2007; Gathercole et al., 2004; Luna et al., 2004). En particular, estos hallazgos son consistentes con aquellos estudios que sugieren un aumento en la capacidad de mantener y actualizar la información en la MT (medida a través de tareas basadas en el paradigma *n-back*) a lo largo de la infancia (Ciesielski et al., 2006; Vuontela et al., 2003). Adicionalmente, los resultados obtenidos con la tarea tipo Sternberg también mostraron algunas mejoras en los procesos de codificación y el mantenimiento de la información verbal cuando se satura el bucle fonológico de la MT. En la versión de la tarea tipo Sternberg empleada en el presente estudio se utilizan tres condiciones de carga en función de la amplitud del conjunto estimular (letras) que debe mantener en la memoria el sujeto: carga baja (entre 3 y 4 letras), carga media (entre 5 y 7 letras) y carga alta (entre 8 y 9 letras). Así, a medida que aumenta la amplitud del número de elementos que hay que mantener (es decir, a medida que se satura el bucle fonológico de la MT), resulta necesaria la implicación del sistema ejecutivo de la MT. Los resultados obtenidos con esta tarea mostraron que el rendimiento de los niños en aquella condición en la que solo estaría involucrado el bucle fonológico (condición de carga baja) se mantiene estable durante todo el período evaluado (no se encontraron diferencias significativas entre T^1 y T^2). Sin embargo, en aquellas condiciones en las que eran necesarios los procesos del ejecutivo central (condición de carga media y alta) se observaron variaciones a lo largo del tiempo (entre T^1 y T^2), siendo significativas las diferencias en la condición de carga media. Estos resultados sugieren que el sistema ejecutivo central necesario para mantener la información en MT cuando se satura el bucle fonológico no está lo suficientemente desarrollado a los 9 años para atender a las demandas y complejidad de la tarea (carga media y alta). El hecho de que solo se encontrara una mejoría significativa en la condición de carga media (y no en la de carga alta) podría deberse a que el ejecutivo central, a pesar de su mejoría, sigue sin estar suficientemente desarrollado como para atender a situaciones más demandantes (como la que se requiere en la condición de carga alta). Dicho de otro modo, los niños cometían más errores a los 9 años que a los 12 en los ensayos de carga media y alta de la tarea. Ya a los 12 años, los niños eran capaces de realizar la tarea significativamente mejor en carga media, pero las demandas de la carga alta aún seguían siendo dificultosas como para alcanzar una diferencia significativa con respecto a su desempeño dos años antes (a los 9 años). Esta hipótesis está respaldada por estudios que han sugerido que el ejecutivo central sigue su trayectoria evolutiva a través de los 10-11 años (Brocki y Bohlin, 2004; Gathercole et al., 2004; Vuontela et al., 2003). Por ejemplo, Brocki et al. (2004) observaron que el desempeño en las tareas de MT (WISC) mejoraba en dos momentos temporales en la muestra evaluada (un total de 4 grupos de niños y niñas con edades comprendidas entre los 6 y los 13 años). Los autores resaltaron las mejoras de los niños y niñas a los 8 años, y desde los 9 a los 13 años. Dichos resultados reflejarían la trayectoria prolongada de la MT, a lo que los autores sugieren que dichos cambios podrían deberse al desarrollo de otros aspectos como las estrategias lingüísticas (fonética y semántica).

Los resultados obtenidos con la tarea de flexibilidad cognitiva empleada en el presente estudio (la tarea de cambio “Número-Letra”), también mostraron mejoras significativas entre las dos evaluaciones (T^1 y T^2). Tanto con las medidas de velocidad (tiempos de reacción) como con las de precisión (porcentaje de errores), se observó como el efecto de coste por cambio de tarea disminuyó entre T^1 y T^2. Estos resultados son respaldados por estudios anteriores que han empleado tareas de cambio (Switching tasks) y han encontrado una evolución a lo largo del tiempo (Davidson et al., 2006; Dick, 2014), sugiriendo que la capacidad para cambiar entre tereas o ‘’sets’’ mentales se desarrolla a través de la infancia, siendo la transición a la adolescencia temprana un período de importantes cambios (Crone et al., 2004).

Por otro lado, con respecto a la capacidad de planificación (medida a través de la Torre de Hanoi), también se encontraron diferencias significativas entre las dos evaluaciones. Estos resultados son congruentes con estudios que han sugerido cambios en esta FFEE a lo largo de la infancia (Luciana et al., 2009; Matute et al., 2008; Vuontela et al., 2003). Sin embargo, cabe resaltar que en el estudio de Matute et al. (2008), en el que examinaron el rendimiento en una tarea de planificación en seis grupos de edades comprendidas entre los 5 y los 16 años, no se observaron diferencias significativas entre el grupo de 9-10 años y el grupo de 11-12 años, aunque a partir de los 13-14 años en adelante sí volvieron a encontrar diferencias significativas entre los grupos. Por el contrario, Luciana et al. (2009) sí encontraron mejoras significativas relacionadas con la edad en la mayoría de condiciones de la tarea de planificación (Torre de Londres), incluyendo los grupos de 9-11 años y 12-14 años.

Sin embargo, con respecto al componente ejecutivo de control inhibitorio (medido a través del efecto de interferencia de flancos obtenido en el *Attention Network Test* -ANT-), no se encontraron cambios significativos entre el T^1 y el T^2. Estos resultados son congruentes con los de los pocos estudios previos transversales en los que también se ha estudiado este aspecto del control inhibitorio a través de una tarea de flancos (Ridderinkhof et al., 1997; Rueda et al., 2004). En estos estudios no se encontraron diferencias significativas a partir de los 7 años, y sugieren que el control o supresión de la interferencia de los distractores podría mostrar un nivel funcional similar al observado en adultos, al menos en tareas de conflicto estimular con estímulos visuales.

En cuanto a las FFEE *hot* exploradas en este el segundo estudio (Inteligencia Emocional -IE- y empatía) no se encontraron diferencias significativas entre el T1 y el T2 ni en las puntuaciones obtenidas en ninguna de las dimensiones del test de IE desarrollado por Chiriboga y Franco (2001), ni en las puntuaciones obtenidas en la Escala Básica de Empatía de Oliva et al. (2011). En otros estudios previos tampoco se han encontrado cambios significativos en estos aspectos del desarrollo socio-emocional durante el final de la infancia media (Byrne y Shavelson, 1996; Keefer et al., 2013). De hecho, dentro de la literatura del desarrollo hay estudios que han sugerido que la estructura del auto-concepto a los 10 años comienza a parecerse a la de los adultos (Keefer et al., 2013; McAdams y Olson, 2010; Soto et al., 2008). A pesar de ello, el período comprendido entre la niñez tardía y la adolescencia temprana sigue siendo clave en el desarrollo de la auto-percepción emocional y la propia personalidad (Soto et al., 2008). La ausencia de cambios en el presente estudio podría deberse al grado de adaptación del individuo al entorno, lo cual podría haber ido consolidándose a lo largo de toda la etapa de Educación Primaria. Por lo tanto, podría ser el cambio de etapa educativa posterior (de primaria a secundaria), el período en el que los individuos podrían presentar cambios más importantes en los dominios socio-emocionales explorados en el presente estudio, e incluso algunos desajustes en la conducta en general, provocado por las demandas del nuevo entorno académico y social (Sosa, 2014). Es por ello que en el estudio del desarrollo del auto-concepto emocional se tengan en cuenta, no solo la edad y las diferencias entre grupos de diferentes rangos de edad, sino los acontecimientos que se dan entre y durante dichos rangos de edad a nivel contextual (por ejemplo, cambio de etapa educativa).

En relación al aprendizaje cooperativo y el desarrollo de las FFEE (*cool* y *hot*) se observó que los niños y niñas que pertenecían al grupo de aprendizaje cooperativo obtuvieron mayores ganancias en el rendimiento de las tareas de MT, así como puntuaciones significativamente más altas en el sub-componente de *autocontrol* del test de inteligencia emocional. En la tarea de tipo Sternberg (MT), el grupo de aprendizaje cooperativo mostró mejoras significativas entre T^1 y T^2 en la condición de carga alta (conjunto estimular previo compuesto por 8 y 9 consonantes). Estos resultados son congruentes con estudios anteriores que han observado un desempeño más alto en tareas cognitivas asociado al aprendizaje cooperativo, particularmente al desempeño de tareas de MT (Gabbert et al., 1986; Logie et al., 1994). Por otro lado, se encontró que el grupo de aprendizaje cooperativo mostró un rendimiento significativo entre T^1 y T^2 en el sub-componente de *autocontrol* de inteligencia emocional. Así pues, aunque hasta el momento no conocemos estudios específicos que hayan encontrado una relación entre aprendizaje cooperativo y autocontrol como componente de IE, algunos autores sugieren que el aprendizaje cooperativo potencia habilidades sociales gracias a las características de las estructuras cooperativas (Gillies, 2014; Johnson, 1980). En términos generales, dichas características, basadas en la interdependencia positiva (relaciones positivas, ambiente de comunicación, apoyo mutuo y atención), podrían contribuir a la motivación del alumnado hacia el propio aprendizaje, y, por ende, a la mejora del proceso de enseñanza-aprendizaje y desarrollo de las FFEE *cool* y *hot* (Gottfried, 1990; Zelazo y Carlson, 2012).

El objetivo principal del ***tercer estudio*** fue examinar longitudinalmente el desarrollo del pensamiento creativo (medido a través del test CREA) en niños y niñas a lo largo del tercer ciclo de educación Primaria. Además, también se exploró el papel mediador de la metodología de aula (aprendizaje cooperativo vs aprendizaje individualista) en las posibles mejoras observadas en el pensamiento creativos a lo largo de este periodo (al inicio del 5º curso de primaria -T^1- y a finales del 6º curso de primaria -T^2-). Los resultados mostraron una mejora significativa relacionada con la edad en el pensamiento creativo a lo largo del mencionado período. Aunque esta mejora fue significativa en ambos grupos de niños, el grupo de aprendizaje cooperativo tuvo un mayor efecto positivo en el rendimiento del pensamiento creativo que el grupo de aprendizaje individualista a lo largo de este periodo. Estos resultados coinciden con estudios previos que sugieren que el rendimiento del pensamiento creativo aumenta a partir de los 9-10 años (Sak y Maker, 2006; Smith et al., 1983; Torrance, 1968). Esto, según Smith et al. (1983), podría ser debido a la maduración cognitiva que acompaña al desarrollo de los niños y niñas en esta etapa de la vida. De hecho, estudios previos han sugerido una evolución del pensamiento creativo hasta el final de la etapa de educación primaria, siendo el período posterior (cambio de etapa educativa) un momento en el que se produciría un declive en el rendimiento en las tareas de pensamiento divergente (por ejemplo, Torrance Test of Creative Thinking) (Gralewski et al., 2016; Kim, 2011; Zyga et al., 2021). En este sentido, Torrance (1968) sugirió que la construcción del propio conocimiento es un acto creativo en sí mismo, pero requiere de un esfuerzo de adaptación a las exigencias curriculares, contextuales y sociales por parte del individuo. Dicho proceso adaptativo podría tener un efecto en la expresión creativa (Maksic y Smiljana, 2021). Dicho de otro modo, la tensión adaptativa producida por las exigencias del entorno escolar podría 'forzar' al sujeto a generar respuestas más apropiadas, aceptables y adaptadas a dichas exigencias (por ejemplo, curriculares), pero en detrimento de aquellas respuestas más novedosas u originales.

Con respecto al papel de la metodología de aula en estas mejoras observadas en el pensamiento creativo, aunque en ambos grupos (aprendizaje cooperativo vs individualista) se observaron diferencias significativas entre el T^1 y el T^2 en las puntuaciones obtenidas en el test CREA, en el T^2 el alumnado que participó en la metodología de aprendizaje cooperativo mostró puntuaciones significativamente más altas que el grupo de metodología individualista. Este resultado es congruente con los de otros estudios previos que también apoyan la eficacia del aprendizaje cooperativo frente al individualista en la mejora del rendimiento del pensamiento creativo en diferentes etapas educativas (Catarino et al., 2019; Marashi y Khatami, 2017; Segundo et al., 2020; Siew y Chin, 2009). Además, estos resultados son convergentes con la literatura que sugiere que las estrategias de aprendizaje cooperativo podrían promover las habilidades de pensamiento de los individuos relacionadas con diferentes dominios. Por ejemplo, Johnson et al. (2000) encontraron asociaciones entre una alta productividad en tareas de razonamiento y pensamiento creativo y el aprendizaje cooperativo. Por otro lado, Marashi y Khatami (2017), basándose en la enseñanza del inglés como segunda lengua, compararon dos grupos (cooperativo e individualista) de estudiantes de secundaria. Los resultados mostraron mejoras significativos en el desempeño de una tarea de pensamiento divergente en el grupo cooperativo (Abedi–Schumacher Creativity Test; ver en Auzmendi y Abedi, 1996). Del mismo modo, un estudio llevado a cabo con estudiantes de secundaria, John y Meera (2014) compararon dos grupos que fueron involucrados en dos tipos de metodología (cooperativo e individualista) en la enseñanza de las matemáticas. Los autores observaron que el aprendizaje cooperativo tuvo un efecto significativo en el rendimiento de una tarea de habilidades de pensamiento creativo (Test of Creative Thinking Skills; John y Meera, 2014). A pesar de los resultados convergentes con este tercer estudio, mayor número de investigaciones son necesarias para observar los efectos del aprendizaje cooperativo en las habilidades de pensamiento creativo, especialmente durante el período transitorio entre la infancia y la adolescencia, en el que se podrían dar un desajuste en el rendimiento creativo debido a los cambios en el desarrollo y las exigencias del entorno educativo (a nivel curricular y/o social).

Por último, el ***cuarto estudio*** se centró en estudiar la relación entre FFEE *cool* (memoria de trabajo, control inhibitorio, flexibilidad cognitiva y planificación) y el pensamiento creativo en niños y niñas con los que se había utilizado distintas metodologías de aula (aprendizaje cooperativo vs aprendizaje individualista) durante el último ciclo de la Educación Primaria. Para ello, la muestra de participantes fue dividida en dos grupos (mediante el análisis clúster) en función de su rendimiento en la *Prueba de Imaginación Creativa* (PIC-N; Artola et al., 2010). Los resultados mostraron diferencias estadísticamente significativas entre los dos grupos (alto vs bajo en pensamiento creativo) en el rendimiento de las dos tareas de memoria de trabajo (2-Back y tipo Sternberg), y en la tarea de flexibilidad cognitiva (tarea de cambio "Número-Letra"), aunque con esta última la diferencia fue marginalmente significativa.

En cuanto a la relación entre MT y pensamiento creativo, según Benedek et al. (2014), el manejo y mantenimiento de la información podría jugar un papel importante en la ideación creativa. La monitorización y revisión de la información se lleva a cabo a través de la continua actualización entre la antigua información y la nueva. En este sentido, la teoría asociativa de la creatividad añade que el pensamiento creativo está asociado a la organización de los conceptos en la memoria semántica (Mednick, 1962). Según esta teoría, el proceso de ideación creativa podría ser interrumpido por representaciones semánticas poco originales y cercanas (evidentes) a un estímulo u objetivo. Es por ello que se espera que las personas altamente creativas superen estas interrupciones para establecer combinaciones conceptuales remotas (menos evidentes) con respecto al estímulo u objetivo (Kenett y Faust, 2019). Por último, la MT parece participar en la identificación de objetivos y en el mantenimiento de las reglas en el desempeño de una determinada tarea ante la distracción interna y externa (Unsworth y Engle, 2007).

La diferencia observada entre los grupos de alta y baja creatividad en el efecto de coste por cambio de tarea obtenido con las medidas de precisión en la tarea de cambio "Número-Letra", también sugiere cierta relación entre este componente ejecutivo de flexibilidad cognitiva y el pensamiento creativo (aunque esta diferencia solo fue marginalmente significativa). Este resultado es congruente con la hipótesis que defiende que el pensamiento creativo requiere de cierta flexibilidad cognitiva ya que la generación de ideas, así como la resolución de problemas, necesita de la habilidad para cambiar entre reglas y criterios para obtener ideas adaptativas a las demandas de una tarea (Benedek et al., 2104).

Los resultados del presente estudio no mostraron relaciones entre el pensamiento creativo y los componentes ejecutivos de control inhibitorio y la planificación. Distintas investigaciones han sugerido que el pensamiento creativo necesita de habilidades de control inhibitorio (por ejemplo, atención selectiva o supresión de la interferencia) (Edl et al., 2014). Sin embargo, otros estudios han sugerido una baja o ninguna asociación entre dichos constructos (Ansburg y Hill, 2003; Benedek et al., 2012; Burch et al., 2006; Fink et al., 2012; Green y Williams, 1999; Memmert, 2007; Stavridou y Furnham, 1996). Por ejmeplo, Rotolo (2016), no encontró relaciones entre control inhibitorio (medida a través de una tarea de flancos) y pensamiento creativo, y sugirió que la relación (positiva o negativa) entre ambos constructos dependería de los instrumentos de evaluación y de la conceptualización del control inhibitorio.

En cuanto a la planificación, los resultados son congruentes con investigaciones anteriores en población infantil y pre-adolescente (Krumm et al., 2020; Sánchez-Macías et al., 2021). La ausencia de asociación entre pensamiento creativo y planificación podría ser debido a la tipología de la tarea. La Torre de Hanoi requiere habilidades para la ordenación de una estrategia (mentalmente proyectar una secuencia de movimientos) para alcanzar una única respuesta, proceso asociado al pensamiento convergente. Por el contrario, la tarea empleada para evaluar el pensamiento creativo en este estudio (PIC-N) ofrece al sujeto la posibilidad de múltiples respuestas o soluciones que implicaría las habilidades de los componentes de pensamiento divergente (elaboración, flexibilidad, originalidad y fluidez). Por tanto, es posible que no exista correlación entre las habilidades requeridas para ambas tareas. Más estudios que analicen estos efectos son necesarios para observar las habilidades implícitas en la ideación creativa y las tareas de planificación.

Por otra parte, los resultados de este cuarto estudio también sugieren cierta relación entre el rendimiento en la tarea de pensamiento creativo (PIC-N) y la metodología de aula. El grupo de alto en pensamiento creativo estaba conformado por un mayor porcentaje de alumnos con los que se había estado utilizando el aprendizaje cooperativo como metodología de aula durante los cursos de 5º y 6º de Educación Primar (71.4%). Por el contrario, el grupo bajo en pensamiento creativo estaba mayoritariamente conformado por alumnos con los que se había estado utilizando el aprendizaje individualista (68.8%). Estas observaciones concuerdan con estudios previos que muestran una relación entre un mejor desempeño en tareas de pensamiento creativo y el aprendizaje cooperativo (Catarino et al., 2019; Marashi y Khatami, 2017; Segundo et al., 2020; Siew y Chin, 2009). De acuerdo con estos resultados, las estrategias de aprendizaje cooperativo podrían involucrar procesos que promueven el pensamiento creativo (estrategias de resolución de problemas y pensamiento divergente) a través del intercambio de ideas basadas en la diversidad de estilos de pensamiento que confluyen en un grupo cooperativo (Kim y Song, 2012).

Por último, también resulta necesario indicar algunas de las principales limitaciones que pueden presentar los estudios que conforman la presente tesis doctoral.

Con respecto al tamaño y características de la muestra de participantes, es importante recordar que los alumnos fueron seleccionados de distintas aulas de dos centros educativos. En estudios futuros, una mayor participación de centros educativos, de alumnado y de profesorado especialista en aprendizaje cooperativo y en otras metodologías de aula, podría ofrecer la oportunidad de extraer información y conclusiones más representativas de cómo las metodologías de aula podrían influir en las relaciones y desarrollo del pensamiento creativo y FFEE.

Por otro lado, en torno al 60% del alumnado procedía de familias migrantes. No obstante, todos los estudiantes nacieron en España o fueron escolarizados a edades muy tempranas en el sistema educativo español, y presentaban un desarrollo de la competencia lingüística que se adecuaba a los niveles exigidos por el currículum escolar. A pesar de ello, podría ser una limitación que las pruebas de creatividad (CREA y PIC-N) fuesen principalmente de componente verbal (Expresión escrita). De la misma manera, la evaluación de las FFEE *hot* exploradas en el presente estudio (Inteligencia Emocional y empatía) se llevó a cabo a través de cuestionarios de auto-informe y aunque fueron desarrollados para niños de edad escolar requieren de un alto nivel de comprensión lectora en relación a los estados emocionales y situaciones de la vida real. Si bien, como se comentó anteriormente, este alumnado poseía un nivel adecuado de competencia lingüística, para estudios futuros con alumnado de estas características sería importante un mayor control de los niveles o grados de bilingüismo para observar su repercusión tanto en las tareas verbales empleadas como en las de rendimiento cognitivo. Además, dadas las características de la población migrante, una más amplia información sobre las características socio-demográficas (hábitos en casa, nivel de educación de la familia, nivel de bilingüismo familiar, etc.) podrían aportar datos relevantes en cuanto a la interpretación de los resultados.

En cuanto a la evaluación de las FFEE *hot* exploradas en la presenta tesis doctoral (Inteligencia Emocional -IE- y empatía), esta se llevó a cabo a través cuestionarios de auto-informe, es decir, a partir de la percepción que el sujeto tiene de sí mismo, desde un plano subjetivo que podría sesgar la interpretación de los comportamientos reales de los individuos en su día a día. Una forma de evitar este sesgo subjetivo podría ser la información observacional de familia o profesorado a través de una evaluación conductual, aportando información sobre el comportamiento en diferentes contextos como son el escolar y el familiar. Además, una evaluación de los procesos emocionales a través de tareas que evalúen el comportamiento en situaciones reales (ej. resolución de problemas) podría ofrecer una información objetiva de dichos procesos. Por tanto, se sugiere para estudios futuros el empleo de tareas que evalúen las características individuales en situaciones de la vida cotidiana y escenarios de toma de decisiones (e.g., Children's Gambling Task; tareas de demora de gratificación), lo cual aportaría información sobre el comportamiento del individuo en tareas con carga emocional.

En cuanto a la evaluación del pensamiento creativo, una de las limitaciones podría ser la carga lingüística que caracteriza los instrumentos de evaluación empleados (test CREA y PIC-N). Si bien, dichos instrumentos son convergentes con componentes clásicos de evaluación del pensamiento creativo (TTCT, Test de Guilford), que además son predictores de los comportamientos en la vida real de los individuos, la escasa intervención de otros dominios (por ejemplo, gráfica o figurativa) podría ser un sesgo en la interpretación el rendimiento real del pensamiento creativo. Por tanto, una medida de pensamiento creativo que permita evaluar diferentes dominios podría extender las posibilidades en el entendimiento del pensamiento creativo.

Otro de los aspectos que podrían limitar nuestras interpretaciones es el ‘’alineamiento” entre las tareas de pensamiento creativo y las FFEE. El diseño de instrumentos de evaluación del pensamiento creativo y de los procesos de las FFEE con características similares (verbales y figurativas) podrían proporcionar información más completa en la relación entre dichos constructos, especialmente, para tareas de control inhibitorio y planificación. En cuanto al control inhibitorio, medido a través de una tarea de flancos (control de la interferencia de distractores), es posible que no sea determinante en el desempeño de las tareas de pensamiento creativo empleadas en la presente tesis. Por otra parte, también hay que señalar que otros aspectos del control inhibitorio, como por ejemplo la inhibición de respuestas automáticas o impulsivas, podrían estar relacionados con el pensamiento creativo. Por otro lado, la tarea de planificación de la Torre de Hanoi, mide principalmente la capacidad del sujeto para encontrar la "única" respuesta a un problema determinado, a través de secuenciar mentalmente los movimientos que lleven a dicha respuesta. Este proceso, aparentemente, parece estar más relacionado con pensamiento convergente que con la habilidad para generar ideas novedosas. Por tanto, una tarea de planificación cuya naturaleza esté más vinculada a las habilidades de pensamiento divergente (flexibilidad, elaboración, fluidez o originalidad) ayudaría a aclarar las relaciones entre planificación y pensamiento creativo.

Por último, una de las limitaciones que es resaltada en los cuatro estudios que conforman la presente tesis es la implicación de las metodologías de aula en cada grupo. En el grupo de aprendizaje cooperativo, la metodología cooperativa se llevó a cabo por el mismo docente en las asignaturas de Lengua y Literatura, Matemáticas y Educación Artística (Plástica y Música) distribuidas en 12 horas semanales; mientras que el resto de asignaturas (Ciencias de la Naturaleza y Sociales, Educación Física y Segunda Lengua) fueron impartidas por docentes especialistas a través de una metodología individualista. La división horaria se debe a que en el sistema educativo español existe la figura del tutor como docente principal, el cual imparte las denominadas materias instrumentales (Lengua y Literatura, Matemáticas y otras, como Educación Artística); mientras que docentes específicos (especialistas) imparten otras materias como Ciencias de la Naturaleza y Sociales, Educación Física y segunda lengua -Inglés y Francés-). Esta asignación de la docencia y los horarios en cada grupo-clase dependen de la gestión de cada de centro. Con respecto al uso de la metodología, el currículum, tanto nacional como autonómico, establece unas líneas concretas en cuanto a contenidos, objetivos y criterios de evaluación, pero no indica de manera expresa el uso de una metodología específica por parte de los docentes. Esto lleva a que cada docente pueda emplear la metodología que más le convengan según sus criterios y objetivos de enseñanza.

En cuanto al grupo individualista, se siguió la misma distribución del profesorado con respecto a las asignaturas, aunque todas ellas se impartieron utilizando la misma estructura metodológica, es decir, una metodología individualista. Es por ello que se considere que la distribución y aplicación de la metodología en cada grupo no estuvo equilibrada. Por lo tanto, sería de esperar que una exposición más proporcionada de las metodologías podría haber ofrecido unos resultados más consistentes con respecto a los efectos del aprendizaje cooperativo en el desarrollo del pensamiento creativo y las FFEE.

6

Conclusiones

e implicaciones

6.1. Conclusiones (*Conclusions*)

De acuerdo a los resultados obtenidos en los cuatro estudios que conforman esta tesis doctoral, podemos extraer las siguientes conclusiones:

1. El pensamiento creativo puede ser potenciado a través de actividades curriculares implementadas a través de la metodología de aula del aprendizaje cooperativo en alumnos de 5º curso de Educación Primaria.

2. El pensamiento creativo y el rendimiento académico correlacionan de manera positiva en niños y niñas en 5º curso de Educación Primaria.

3. Durante la etapa escolar comprendida entre los 9 y los 12 años de edad, los niños muestran mejoras significativas en el rendimiento de tareas de FFEE *cool* como la MT, la flexibilidad cognitiva y la planificación, mientras que en el componente de control inhibitorio implicado en la supresión o control de la interferencia de los distractores no se observan cambios significativos.

4. La auto-percepción de otras FFEE socio-emocionales, en ninguna de las dimensiones evaluadas (auto-conciencia emocional, auto-control, auto-motivación, habilidades sociales y empatía), no manifiesta cambios significativos durante el tercer ciclo de Educación Primaria (9 a 12 años).

5. El aprendizaje cooperativo, como metodología de aula, puede potenciar las mejoras en el componente ejecutivo de la MT, así como la auto-percepción que tienen los niños y niñas

de sus habilidades de auto-regulación emocional, durante el tercer ciclo de Educación Primaria (entre los 9 y los 12 años de edad).

6. El pensamiento creativo presenta una mejora significativa durante el tercer ciclo de Educación Primaria (entre los 9 y los 12 años de edad).

7. Los niños y niñas del último curso de la Educación Primaria con mejores puntuaciones en pensamiento creativo, muestran también un rendimiento significativamente mejor en tareas de MT y flexibilidad cognitiva en comparación con aquellos niños y niñas con peores puntuaciones en pensamiento creativo

8. El aprendizaje cooperativo se asocia a un mayor rendimiento en pensamiento creativo en comparación con el aprendizaje individualista en niños y niñas de 6º curso de Educación Primaria

De acuerdo con el apartado 1 del Artículo 32 de la normativa de estudios oficiales de doctorado de la Universidad de Almería, aprobado en Consejo de Gobierno de 29 de octubre de 2020, en la que se contemplan los requisitos para la obtención del título de ''Doctor Internacional'', se desarrollan las conclusiones de la presente tesis doctoral, enumeradas anteriormente, en una lengua extranjera habitual para la comunicación científica en este campo de conocimiento, y distinta a cualquiera de las lenguas oficiales o cooficiales de España. A continuación, se redactan dichas conclusiones, al igual que el resumen anteriormente desarrollado, en lengua inglesa:

According to the results obtained, the conclusions of the present doctoral thesis are:

1. Creative thinking can be enhanced through curricular activities implemented through the classroom methodology of cooperative learning in students in the 5th year of Primary Education.

2. Creative thinking and academic performance correlate positively in boys and girls in the 5th grade of Primary Education.

3. During the school stage, between 9 and 12 years of age, children show significant improvements in the performance of cool executive functions tasks such as working memory, cognitive flexibility and planning, while no significant changes are observed in the inhibitory control component involved in the suppression or control of the interference of the distractors.

4. The self-perception of other socio-emotional executive functions, in none of the dimensions evaluated (emotional self-awareness, self-control, self-motivation, social skills and empathy), does not show significant changes during the third cycle of Primary Education (9 to 12 years).

5. Cooperative learning, as a classroom methodology, can enhance improvements in the executive component of working memory, as well as the self-perception that children have of their emotional self-regulation skills, during the third cycle of Education Primary (between 9 and 12 years of age).

6. Creative thinking shows a significant improvement during the third cycle of Primary Education (between 9 and 12 years of age).

7. Boys and girls in the last year of Primary Education with better scores in creative thinking also show significantly better performance in working memory and cognitive flexibility tasks compared to those boys and girls with worse scores in creative thinking.

8. Cooperative learning is associated with higher performance in creative thinking compared to individualistic learning in boys and girls in the 6th grade of Primary Education

6.2. Implicaciones

El conjunto de los resultados de la presente tesis doctoral muestra la importancia del estudio del desarrollo y las relaciones entre pensamiento creativo y FFEE durante el período escolar, así como las implicaciones de las metodologías de aula durante dicho período. La edad escolar es una etapa en la que los niños y niñas se enfrentan a grandes cambios a nivel de desarrollo, tanto cognitivo como socio-emocional, además de afrontar la compleja tarea de adquirir las destrezas y competencias individuales que les permitan afrontar desafíos adaptativos en el día a día de su contexto social y cultural.

Por tanto, la presente tesis doctoral pone de manifiesto la importancia del estudio de dos importantes constructos (pensamiento creativo y FFEE) para la mejora de los contextos educativos, así como los procesos de enseñanza-aprendizaje. La evaluación neuropsicológica infantil y la investigación educativa también deben estar enfocadas en la potenciación de los recursos dentro del aula, tanto humanos y materiales como pedagógicos. Por tanto, el estudio del pensamiento creativo y/o los procesos cognitivos y socio-emocionales dentro del aula debe servir para enriquecer las estrategias docentes y el impulso del aprendizaje competencial; ofrecer oportunidades de aprendizaje de una manera integradora, igualitaria y adaptada a las necesidades y ritmos de desarrollo del alumnado.

Así pues, investigaciones futuras deben estar basadas en la integración de todos los agentes que conforman la realidad de los niños y niñas dentro y fuera del contexto escolar. El estudio sistemático de estos agentes o variables nos permitirían profundizar en la relación que existe entre estos y mejorar la realidad escolar. Por tanto, generar una relación fluida entre el estudio del desarrollo en la etapa infantil y la observación de las estrategias metodológicas, es una finalidad que no debe obviarse en el ámbito investigativo y educativo en favor a la mejora de la calidad de la enseñanza.

7

Publicación y divulgación de resultados

A continuación, se detalla la actividad divulgativa derivada del trabajo de la presente tesis doctoral, la cual se ha organizado por el tipo de publicación y fecha.

Artículos científicos

Segundo Marcos, R. I., López Fernández, V., Daza González, M. T., & Phillips-Silver, J. (2020). Promoting children's creative thinking through reading and writing in a cooperative learning classroom. *Thinking Skills and Creativity*, *36*, 100663. https://doi.org/10.1016/j.tsc.2020.100663

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Comunicaciones orales

Segundo Marcos, R. I., López Fernández, V., & Daza González. M.T. (Abril 2016). *Neuropsicología aplicada al contexto educativo: desarrollando la creatividad en el aula*. I Jornada de transferencia de transferencia del conocimiento del grupo de investigación NNCS (CTS-001). Universidad de Almería.

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Segundo Marcos, R. I., López Fernández, V., & Daza González. M.T. (Mayo 2018). *Creatividad y funciones ejecutivas en niños de educación Primaria*. II Congreso Iberoamericano de Neuropsicología y XIV Congreso de la Sociedad Andaluza de Neuropsicología.

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Posters

Segundo Marcos, R. I., Daza González. M.T. & López Fernández, V. (Marzo 2016. Zaragoza). *Neuropsicología Educativa: efecto de un programa para el desarrollo de la creatividad en Educación Primaria.* VIII Congreso Nacional de Neuropsicología Fanpse.

Segundo Marcos, R. I., Daza González. M.T. & López Fernández, V. (Marzo 2019. Madrid). *Memoria de trabajo y control ejecutivo. Estudio correlacional en población infantil.* XI Congreso Nacional de Neuropsicología Fanpse.

Segundo Marcos, R. I., Daza González. M.T. & López Fernández, V. (Junio 2019). *Memoria de trabajo y pensamiento creativo en niños de educación Primaria.* 16th NR-SIG-WNR Conference and 15th SANP Congress.

Divulgación científica

Participación en La Noche europea de los Investigadores 2017. *Neurociencia cognitiva para todos.* Grupo de investigación NNCS (CTS-001). Proyecto europeo Openresearchers, aprobado por la Comisión europea Marie SKlodowska-Curie Actions.

Participación en La Noche europea de los Investigadores 2018. *Cómo funciona nuestra mente.* Grupo de investigación NNCS (CTS-001). Proyecto europeo Openresearchers, aprobado por la Comisión europea Marie SKlodowska-Curie Actions.

Estancias de investigación

Estancia de investigación en la Universidad de la Habana (diciembre 2019- marzo 2020), financiada por el Grupo de Universidad de La Rábida (España).

8

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