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Are movies making us smarter?
The role of cinematic evolution in the Flynn Effect.

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Standardised IQ tests have charted massive gains over the last century, known as the *Flynn Effect*. Over the same period, the time society spends with screens has massively increased and the composition of popular Western movies has intensified, e.g. shorter shot durations, closer shots, increasing narrative complexity. In *Movies on our Minds: The Evolution of Cinematic Engagement* (2021), James Cutting suggests a potential bidirectional link between the two effects: generational increase in visual processing abilities led to movie makers increasing the demands their movies place on viewer cognition, which in turn has trained societal visual processing capacity. In this commentary we review the empirical evidence for the predicted positive association between screen time and visual processing abilities. The evidence indicates that increasing exposure to intense screen experiences may be associated with faster visual processing, but a potentially *decreased* ability to use and reason about this information (i.e. reduced executive functions). Further, effects may be dependent on the type of screen experience (e.g. developmental appropriateness of content and content delivery platform such as TikTok) and other environmental considerations (e.g. socioeconomic status, parenting) suggesting that the factors influencing our evolving media/mind niche may be more complex than originally proposed.

Over the last century, human life has become increasingly saturated with screen media. At the end of the 19th century, cinema first provided an opportunity for people to experience moving images, first as simple short “slice-of-life” films and then increasingly as longer duration, narratively and formally more complex feature films. Moving images were only experienced occasionally in cinemas but once the technology had moved into our homes (Television in 1950s) and later our hands via mobile technologies (e.g. smartphones in 2000s), the frequency with which screen media was consumed exploded. Average weekly “screen time” between 1930 and 1950 would have been ~2-5 hours for a US adult attending a Cinema once a week (Pautz 2002). By the end of the 1950s, when more than 80% of US households owned a TV (Britannica 2022), the average weekly time spent watching TV was around 14 hours (Livingstone 2009). Today, the presence of smartphones and tablets, the increase in computer-based office work and the tendency to use multiple screens simultaneously means that the global average time an adult spends on a screen is around 72 hours per week (Kemp 2022), nearly two-thirds of their waking life.

As the volume of screen media has increased so has its intensity. No one has documented this change more accurately and convincingly than James Cutting. Across many publications and his book, *Movies on our Minds: The Evolution of Cinematic Engagement* (2021), Cutting has applied advanced "counting" (as he calls it) to track formal, stylistic and storytelling features throughout Cinema's history and provide an impressive evidence-base for the oft stated observation that film has intensified over the last century. By analysing 300 of the most popular Hollywood films spanning 1915 to 2015, Cutting demonstrates that shot durations have decreased and there has been an *"extinction of the fade/dissolve/cut paradigm of transitions, ..an increase in shot scale of returning establishing shots, the decrease in the duration and number of conversations, and the increase in the use of syntagmas [narrative units]"* (Cutting 2021; 320). Cutting's data reinforce the observations of film historians (e.g. Salt 1983; 2006; Bordwell 2006) and the changing practices of modern filmmakers (AMPAS 2014). But what brought about this change? This article will examine the empirical evidence for the hypotheses that Cutting puts forward for the cognitive basis of this evolution.

In Cutting's book, he suggests that the properties of film that have changed over the last century may have done so because "*the aspects of our **movie/mind niche** have gradually changed during the past century through the **Flynn effect** and **our intensified visual education**….these changes seem grounded in effects of social learning and culture. The period-like eyes and minds of our grandparents were not the same as those of our grandchildren." (Cutting 2021; 320).* There are several key parts to this hypothesis so let's unpack them.

Our movie/mind niche

Cutting's hypothesis is predicated on the assumption that an objective of mainstream filmmaking is to entertain, and a prerequisite of entertainment is for its consumption to be enjoyable and effortless. As such, for a particular profile of movie features to be "selected" and propagated to future generations of movies they must piggy-back on our existing cognitive skills and biases. This ecological view of movie perception has a long history (Gibson 1979; Anderson 1998; Berliner and Cohen 2011; Smith, Levin and Cutting 2012). Although radically different to real-world audiovisual scenes, movies must co-opt the cognitive skills we have learned during typical neurocognitive development to ensure their content can be perceived and comprehended by as broad an audience as possible without requiring too many specific skills to be learnt (see Schwan and Ildirar 2010 for some exceptions). By being yoked so closely to typical human socio-cognitive development, movies must constantly aim to adapt to any changes in these biases across generations to ensure they continue to fit the *movie/mind niche*.

The Flynn Effect

What is the evidence that this niche changes over time? Here Cutting cites the "Flynn Effect", so named by Herrnstein and Murray in their book *The Bell Curve* (1994) after James Flynn, the psychologist who first discovered the effect. James Flynn noticed a systematic rise in standardized intelligence test scores between 1932 and 1978 among industrialized Western samples (Flynn 1984). Periodic renorming of standardized intelligence quotient (IQ) tests with new samples revealed an IQ creep as the mean score for the normative sample increased. This effect has been replicated many times including in a meta-analysis of 285 studies since 1951 which revealed a mean increase of 2.31 standard score points per decade (Trahan et al. 2014), and is also observed in non-Western nations including Japan, South Korea and rural Kenya (Daley, et al 2003; Flynn 1987; Te Nijenhuis et al. 2012). Certain subtests increased more than others. Raven's Progressive Matrices, a non-verbal test of abstract reasoning and fluid intelligence rose by 14 IQ points between 1942 and 2008 (Flynn 2009). Raven's questions consist of visual geometric shapes presented in a sequence with one of the shapes missing. The participant's task is to select the missing shape from several candidates by figuring out the visual progression (i.e. change in shape, lines or shading) between the presented shape sequence and applying it to the partial sequence. Participants who do better on the Raven's test are believed to have better "general cognitive ability" (Raven 2003) and the test is therefore commonly used as a proxy for IQ. Some studies have reported a slowing down or even a reversal of the Flynn effect in some Western countries in recent years (Dutton and van der Linden 2016) although this decline is under debate with cross-nation reviews continuing to show an increase (Trahan et al. 2014). Whether societal gains in tests such as Raven's should be interpreted as the population getting "smarter" is also under debate with both Cutting and Flynn (2007) preferring to interpret the gains more specifically as individuals getting "faster at extracting information from visual displays" (Cutting, 2023).

The Enhanced Visual Processing hypothesis

What may be causing the Flynn Effect? Various hypotheses have been put forward, including those arguing that the effect isn't an indication of actual IQ increase, such as increased familiarity with test taking or increased motivation to score well. But other hypotheses do support the interpretation that IQ, as assessed by these tests, is increasing. These factors include increased global nutrition, health care, education, and child-rearing practices that have created better conditions for healthy cognitive development (Neisser 1987). However, Cutting focusses on one proposed factor: an increase in the everyday visual and technical environment: *"children are [increasingly] being raised in cultures that afford ubiquitous access to pictures, graphs and displays of all kinds…. [acquiring] the skills of information extraction and visual reasoning at an early age*." (Cutting 2021; 130). Before the 20th century, the volume and variety of visual displays individuals were exposed to was highly limited. Throughout the 20th century the complexity of visual displays has massively increased and permeated all aspects of daily life, especially in the urban environments. Children are educated through illustrated textbooks and entertained by TV, online videos, apps and increasingly visually rich, immersive and demanding videogames. Various theorists have proposed that this explosion in the complexity of our visual environments has resulted in changes in our visual processing capacities (Neisser 1987; Flynn 2007; Kubey and Csikszentmihalyi 2002; Posner and Rothbart 2015), which are specifically tapped by standardized IQ tests like Raven's Progressive Matrices. Cutting also adopts this hypothesis and expands it into a bidirectional explanation of why the movie/mind niche has changed over the last century:

1) the visual processing capacity of the population increased, partly due to increasing exposure to movies, and
2) in turn, movies intensified to accommodate the enhanced visual processing abilities of their audiences.

This seemingly never-ending movie/mind arms race is believed to be fueled by the desire of filmmakers to enhance engagement whilst dealing with an ever more visually-skilled audience who require more from their visual experiences to provide the same level of engagement (Berliner 2017).

The impact of movies on visual processing

Here, I will take as a given the descriptive evidence for the second component of Cutting's movie/mind arms race. Cutting and others (Salt 1983; 2006; Bordwell 2006) have documented the intensification of film form over the last century and the oft-replicated Flynn effect has documented simultaneous increases in visual processing. But what is the evidence that visual processing increases due to exposure to movies? Cutting states this hypothesis as "*the sheer exposure to movies has surely educated us to certain visual forms and helped us extract information more quickly*" (Cutting 2021; 131). What is the evidence in support of this hypothesis?

Correlational evidence

As it is difficult to analyse how historic changes in film form might have enhanced the visual processing ability across generations, we will instead start by looking for evidence of similar positive correlations within a generation, i.e. cross-sectionally. To do so requires a large sample of individuals who report their movie viewing habits and visual processing abilities. No such data exists for movie viewing but it does for daily TV exposure, probably due to the larger volume of contemporary TV compared to cinema-going and the long-standing debate about the evils of TV (Leick 2018; Smith, Mital and Dekker 2021). Studies on this topic, including meta-analyses reveal that, contrary to Cutting's implied positive association, there is commonly a negative association between higher TV exposure and lower Raven's scores (Ribner, Fitzpatrick and Blair 2017), poorer executive functions (a suite of cognitive skills such as attention control, inhibitory control, working memory and cognitive flexibility, required for deliberate thought and behaviour; Ribner, Fitzpatrick and Blair 2017), and greater traits of Attention Deficit and Hyperactivity Disorder (Nikkelen et al. 2014), a neurodevelopmental disorder characterised by difficulties with control of attention, visual processing and behaviour regulation (e.g. Rommel et al. 2015). However, caution must be taken in overinterpreting these associations as they are often confounded by other factors including family socioeconomic background, the type of content viewed, and child age (Kostyrka-Allchorne, Cooper and Simpson 2017). The direction of effects – whether screen time changed cognition, or children with different cognitive profiles are differentially drawn to screen time - cannot be known from cross-sectional studies.

Longitudinal Studies

Longitudinal studies offer a better way of examining how exposure to moving images may influence individual differences in visual processing. A longitudinal, developmental approach gets closer to the temporal ordering of the societal effect implied by Cutting. By repeatedly measuring an individual's media exposure and their visual processing abilities over childhood we can test whether changes in one precedes changes in the other, establishing the critical temporal ordering of factors that are a necessary, but not sufficient, criteria for interpreting causation. Several studies of TV have taken this approach and the resulting picture is complex. Early TV exposure has been shown to be associated with difficulties in later executive function and general cognitive performance as well as increased attention problems, but these effects are mostly restricted to children who are exposed to high levels of TV during infancy/toddlerhood, from disadvantaged socioeconomic backgrounds, and presented with inappropriate/non-educational content (see Kostyrka-Allchorne, Cooper and Simpson 2017 for review). When the TV content presented is age-appropriate or scaffolded by parental support, the longitudinal impact of TV exposure on developmental outcomes either goes away or becomes beneficial (e.g. Barr, et al. 2010).

Evidence for the potential heightened impact of screen time during infancy/toddlerhood, combined with the recent rise in infant touchscreen device use (bringing the intense visual stimulation closer to the child; Bedford et al. 2016) motivated us to conduct the Toddler Attentional Behaviours and Learning with Touchscreens (TABLET) longitudinal study. Infants were recruited into our study based on whether their daily exposure to touchscreen devices (mobile phones or tablets) was above (High Users) or below (Low Users) the average at 12 months-of-age. Their attention and visual processing abilities were assessed using gaze-contingent eye tracking tasks in the lab at 12-months, 18-months and 3.5-years-of-age. We found that High Use infants were faster to detect a visually salient red apple amongst blue apples in a visual search task (Portugal et al. 2020), faster to orient to peripheral stimuli in saccadic reaction time tasks but *slower* to disengage and shift attention from central stimuli and more likely to saccade to a distractor instead of learning to inhibit this automatic response as required by the task (Portugal et al. 2021). These findings suggest that High Users were faster at processing visual stimuli and their attention was more controlled by the salience of the stimuli (i.e. exogenously driven by the environment) and that they may have been poorer, or at least not better, in deliberate cognitive control of attention (i.e. endogenous or voluntary attention control). Our findings suggest that High Users may also struggle to deliberately act on the information extracted (Portugal et al. 2021). This interpretation was supported by behavioural assessments of executive functions (EF) in the same sample at 3.5-years. Using a combination of screen-based and real-world EF tasks, toddlers who had high touchscreen use showed significantly reduced working memory and cognitive flexibility. This effect became non-significant when controlling for background TV, suggesting that these effects may be due to the overall media environment not specifically to touchscreen exposure. Impulse/Self-control was not significantly associated with touchscreen use but was negatively associated with non-child-directed television (i.e. more TV exposure associated with lower impulse control; Portugal et al. 2022). The longitudinal design of the TABLET study allowed us to control for pre-existing confounds such as age, sex, socioeconomic status, child IQ and temperament as these were matched in the High and Low Users at the start of the study (12–months-of-age), suggesting that the screen exposure may be the driving factor in these EF differences. However, both the attention control and EF differences between High and Low Users were only significant when considering concurrent use (at the time of assessment) or stable high versus low use over the last 2.5 years, meaning that it isn't clear whether it was the earlier exposure that caused later developmental differences or the current exposure having a short-term impact.

Experimental evidence of immediate impacts

Such short-term impacts of screen time on visual processing, attention and EF are commonly reported. During movie viewing, whilst it may appear that audience members are physically passive, experimental psychology studies have shown that they are cognitively highly active. Their eyes seek out visual information, shifting across the screen 2-to-5 times a second (Smith 2013), attending to and encoding new information so they can construct and test mental models of the narrative (Loschky et al. 2020). As the visual complexity of a cinematic image increases and the editing gets faster so does viewer attention (Smith 2013*).* Immediately following a cut, the duration of each eye fixation is shorter, saccadic eye movements (i.e. overt attentional shifts) are larger (Smith and Mital 2013), gaze is biased towards the screen centre, more systematic between all viewers (Smith and Mital 2013; Mital et al. 2011) and more driven by visual salience (Mital et al. 2011; Carmi and Itti 2006) than later in the shot. These changes in eye movements over the duration of a shot suggest a shift from exogenous to endogenous attention control (Smith and Mital 2013). If a movie is edited very rapidly or includes a lot of motion (either through a mobile camera or very precise staging of the focal action) the degree to which gaze is under endogenous control may be highly limited (Smith 2013; Loschky et al. 2015).

These within-viewing effects of movie viewing may also immediate spill-over to visual processing after viewing. Attention Restoration Theory (ART; Kaplan 1995) argues that endogenous attention control is a finite resource that is effortful and can be fatigued if over-challenged by a visual experience such as walking through a city street and restored by less demanding sensory experiences such as a park. For example, urban street environments place heightened demands on attention via frequent and highly salient events such as traffic, car horns, billboards, and pedestrians. In such an environment our attention will be under heightened exogenous control, but in order to successfully navigate a street, we will need to use endogenous control to inhibit distraction, focus attention on the path ahead whilst also being sensitive to salient threats, e.g. an approaching car as we cross the road, and voluntarily respond to it. Such urban environments have been shown to lead to worse performance on tests of endogenous attention compared to rural environments (e.g. Bermen, Jonides and Kaplan 2008). Critically, such restoration (rural) and depletion (urban) effects have been shown for videos as well as the real environments (Bourrier, Berman and Enns 2018). Urban videos likely include greater motion, more identifiable entities (e.g. people and vehicles), more changes of context and generally more areas of interest to be investigated by the viewer's eye movements than nature videos (e.g. Berto, Massaccesi, and Pasini 2008), resembling the intensified pattern of formal features identified in recent movies (Cutting 2021). If exposure to such cinematic features were resulting in immediate boosts in viewer visual processing, as implied by Cutting's hypothesis we would expect better performance after viewing urban videos compared to nature videos. In fact, the ART video-viewing literature suggests the opposite. Urban videos lead to worse performance on backward digit span tasks (a measure of working memory and sustained attention) and no difference in Raven's Progressive Matrices (Bourrier, Beman and Enns 2018).

Comparable evidence of an immediate negative impact of video viewing on attention and voluntary visual processing comes from work on executive function depletion in children

(Geist and Gibson 2000; Kostyrka-Allchorne, Cooper, Gossmann, Barber, and Simpson 2017; Kostyrka-allchorne *et al.* 2019; Kostyrka-Allchorne, Cooper, and Simpson 2019; Lillard et al. 2015; Lillard and Peterson 2011). After watching episodes of SpongeBob Square pants, an intense and fantastical kid's cartoon, 4-year-old children perform worse on real-world EF games such as the Tower of Hanoi or backwards digit span task than when they either watched an educational show or drew for the same length of time (Lillard and Peterson 2011). Subsequent studies argued that the EF depletion effect was due to the presence of cognitively-tasking fantastical content rather than the pace of editing (Lillard et al. 2015). Although, through re-analysis of the shows used in these studies we have recently shown that the EF-depleting kid's TV shows also differ in low-level stimulus features such as image flicker (a proxy for motion), image complexity and editing rate, although surprisingly slower editing was more depleting (Essex et al. 2022). In a direct lab-based assessment of attention in which content and pacing were independently manipulated, Kostyrka-Allchorne and colleagues showed that faster paced videos resulted in *faster* attention when paired with realistic content but worse inhibitory control (Kostyrka-Allchorne et al 2017; Kostyrka-Allchorne, Cooper and Simpson 2017; 2019). These immediate-impact findings mirror the findings of our TABLET study: faster attention/visual processing but poorer executive function.

Does this evidence support Cutting's Enhanced Visual Processing hypothesis for why movies are intensifying? Cutting's conjecture that exposure to movies has educated viewers to "*extract information more quickly*" (Cutting 2021; 131; Cutting, 2023) does seem to be supported by evidence for faster attention from short-term intervention studies (e.g. EF depletion and ART studies), as well as our longitudinal study of touchscreen use in toddlers. However, importantly, this seems to come at the cost of the cognitive skills necessary to potentially use that information, i.e. endogenous attention and some executive functions. This change may come about either by a) rewarding faster exogenous orienting during the intense repetition of highly salient moments in AV media (e.g. across cuts of increasing frequency), b) limiting the opportunities for practicing and improving endogenous/executive control especially during childhood when EF is developing, or c) repeatedly fatiguing endogenous resources during the push-pull of exogenous-endogenous control of attention during screen time leaving less capacity for endogenous control outside of screen experiences. Currently these mechanisms have not been directly tested as the only way to show a direct causal impact of screen time on attention control and visual processing would be to intervene in an individual's screen time whilst the rest of their daily routines remain the same. Such randomized controlled trials of screen time with the precise measures of attention outcomes required have not been conducted (Jones et al. 2021). Lab screen time interventions (e.g. ART and EF depletion) may show short-term impacts but evidence of the long-term causal impacts required to fuel a societal shift in visual intelligence like the Flynn Effect do not exist.

Faster ≠ Smarter

Cutting also claims that the Flynn Effect may be driving the increase in narrative complexity of popular movies (Cutting 2023). Cutting acknowledges that this change would require viewers to *"extract and then hold more fragments of narration in mind as the movie unfolds [which can be] intellectually challenging"* (Cutting 2023; XX). However, we have demonstrated above that individuals with greater screen time show less of the cognitive skills required to comprehend complex narratives (e.g. endogenous attention, executive functions including working memory; Portugal et al. 2020; 2021; 2022). Children with ADHD, a neurodevelopmental disorder characterised by poorer EF, exhibit story comprehension difficulties (Flory et al. 2006), and adults with lower working memory capacity draw fewer inferences in movies (Hutson et al. 2021). But this negative evidence is countered by opposing positive evidence that cinematic “literacy” increases with movie experience (Messaris 1994) and that viewers learn how to perceive events across certain types of edit (Schwan and Ildirar 2010). The basic building blocks of movie perception and comprehension may be a byproduct of typical neurocognitive development (Ildirar and Smith 2018) but only through experience with more challenging movie structures can we learn how to understand them (Smith 2012a; 2012b). How we reconcile the apparent contradiction between individuals both increasing their movie “literacy” whilst also decreasing their cognitive capacity to comprehend complex narratives is unclear. One explanation could be the difference between immediate fatigue vs. long-term training. After a strenuous run our muscles are fatigued and work less well. But if we run regularly our stamina will improve. Similarly, the cognitive challenge posed by complex narratives may fatigue EF during watching, but over repeated exposure we may develop the cognitive skills necessary to ease their processing. Such long-term benefits may not be evident in lab-based or questionnaire measures of EF or visual processing due to the generic nature of the tests. The cognitive benefits may be specific to the domain of movie narrative comprehension and not transfer to more general applications (such absence of transfer is often seen in brain training; Nguyen, Murphy, and Andrews 2021).

Who are these increasingly complex movies made for?

During the mid-20th Century, it could be argued that the dominance of movies in popular Western culture meant that any changes to movie form (e.g. increasing editing rate or narrative complexity) would be experienced by a high proportion of the population. By sampling some of the most highly rated movies during each five-year period, Cutting provided a very coarse snapshot of the evolution of average screen experience during the 20th Century. But since the turn of the century the increasing multiplicity of screen devices and delivery platforms through which we consume audiovisual media (e.g. Cinemas, Broadcast TV, Netflix, YouTube, TikTok, etc) has meant that feature-length movies are simply one component of a rich and highly varied screen culture. This switch to new modes of viewing is even more apparent in children. In the UK in 2022, children (3- to 17-year-olds) are more likely to watch programs via streaming services (78%) than live TV (47%) with only 33% of children watching whole TV programmes or movies compared to 65% watching short funny videos on platforms such as YouTube and TikTok (OfCom 2022). TikTok uses algorithm-based presentation to show a continual stream of short-format videos, which contain many intense compositional features (rapid editing, intense soundtracks, superimposed text and graphics). TikTok’s popularity is increasing due to its ease of use and heavy emphasis on automatic personalization: *“On YouTube you have to decide what to watch all the time and sometimes I can never think what to pick… But on TikTok it just comes up for you.”* (Zak 12; OfCom 2022; 29).

As this algorithm-driven, rapid-fire video viewing screen culture displaces the traditional feature-length experience of previous generations can we still argue that Cutting's "mind/movie" niche is relevant in driving population change in visual processing? Future researchers continuing Cutting's pioneering work must begin to capture the broader range of screen experiences of today's audiences. Older viewers may be able to process the increasingly complex movie narratives as their executive functions were spared by the relatively less intense screen experiences of their youth. Whether the current TikTok generation have the profile of cognitive skills necessary to follow Hollywood's increasingly knotty narratives, or even the inclination to try given the ease and immediate reward of short-format video viewing is unknown.

Do movies make us smarter?

The evidence presented here does not support the hypothesis that increasing exposure to intensifying movies, TV or touchscreens are associated with a general IQ advantage. Admittedly, Cutting did not claim a general increase in intelligence, nor did Flynn (2007). Cutting's specific prediction that visual processing has quickened over time in line with the intensification of movies is supported by longitudinal and experimental evidence (Kostyrka-Allchorne, Cooper and Simpson 2017; Portugal et al. 2020; 2021; 2022) but the potential impact that the corresponding decrease in executive functions may have on comprehension is not yet known. We must also consider that an individual's screen exposure does not exist in isolation and other societal changes such as nutrition, health care, schooling, parenting, and increased urbanization also likely contribute to the Flynn Effect and the expanding media/mind niche within which modern children and emerging technologies coexist. Cutting's provocative work provides an important methodological and theoretical framework that must be extended to quantify the rapidly changing media/mind niche.

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