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Giotto’s applications of embodied perception: Lateral and vertical dimensions of space

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Giotto’s Arena Chapel frescoes, dating from the early fourteenth century, provide salient illustrations of two types of embodied perceptions. One is universal, a consequence of biology and the physical laws of nature, linked to the vertical dimension of space, and impacting on affect and moral judgement. The other is culturally determined, acquired from the direction of reading script and affecting perceptions of directions of movement, time and causality. Giotto’s intuitive use of embodiments, the result of a newly evolving realism in painting, may have prompted late mediaeval chapel-visitors to empathize with the storied biblical characters, so that figures that were once only the object of religious veneration and awe were now made into living beings with a shared humanity, resulting in an awakening of a personal agency that fueled the Renaissance and Modernism.

Keywords: Laterality; Verticality; Embodiment; Personal agency; Giotto.

The art of Giotto di Bondone (c. 1266–1337) was, as it is today, much admired and respected. His realism not only broke with Byzantine tradition, but set the stage for the Renaissance and perhaps even the growth of individualism that characterizes modernity. The major source of Giotto’s fame and influence resides in the Arena Chapel in Padua where he painted a world of storied characters to which spectators could relate empathetically. In frescoed narratives that embraced the lives of Joachim and Anna, the Virgin Mary and Jesus, Giotto portrayed palpably human figures in a realistic three-dimensional space, where they visibly walked, talked, expressed emotion, gesture and even conspired. Giotto’s greatness, however, went beyond the advancement of new painterly techniques and qualities. The entire decorative enterprise of the Arena Chapel is marked by a well-defined rationality that can be seen within each fresco as well.

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as in the larger interlocking spatial, temporal and moral framework that encompasses it.

The chapel, built from pinkish brown brick, is a modest, rectangular, barrel-vaulted structure. Although the identity of the architect has been the source of debate (e.g., Jacobus, 2008; Radke, 2004), it was ideally suited for displaying Giotto’s masterwork. The public entrance to the chapel is through a door in the west wall, above which is the Last Judgment. On the eastern end of the chapel, God the Father sits above a grand arch that separates the nave from the small chancel. Below God, in the spandrel space on either side of the arch, Gabriel and the Virgin Mary enact the Annunciation scene.

Of the 36 frescoes that comprise the four narrative cycles, 18 occupy the long south wall and 16 the long north wall. The remaining two frescoes are positioned on either side of the chancel arch. As can be seen in a map of the Arena Chapel (http://www.wga.hu/support/viewer/z.html), the first and earliest cycle, the Life of Joachim, begins on the upper register of the south wall, next to the chancel arch, with Joachim Driven from the Temple, and continues westward with Joachim Joins the Shepherds, Annunciation to St. Anna, Sacrifice of Joachim, Joachim’s Dream and Meeting at the Golden Gate, the latter of which reaches the west end of the south wall.

The second cycle, the Life of Mary, continues on the third register of the immediately opposite west wall. The cycle begins with the Birth of the Virgin, and again continues in a temporally ordered fashion, Presentation of the Virgin in the Temple, Ceremony of the Rods, Prayer for the Miracle of the Rods, Marriage of the Virgin, ending with the Wedding Procession next to the chancel arch.

The third cycle, the Life of Christ, begins with the Visitation on the south pillar of the chancel arch and continues westward on the second register with the Nativity, Adoration of the Magi, Presentation of Jesus in the Temple, Flight into Egypt, reaching the west wall with the Slaughter of the Innocents, crossing to the opposite wall to Christ among the Doctors, and continuing back towards the chancel arch with the Baptism of Christ, Marriage Feast at Cana, Raising of Lazarus, Triumphal Entry into Jerusalem and Cleansing of the Temple.

The fourth cycle, The Passion of Christ, begins with the Betrayal by Judas on the north pillar of the chancel arch, skips across the arch (see below) and courses down the second register on the north wall, Last Supper, Washing of the Feet, Kiss of Judas (Arrest of Christ), Jesus before Caiaphas, Mocking of Christ, Road to Calvary, the Crucifixion, Lamentation (Deposition; Pieta), Noli me Tangere (Resurrection), Ascension, Pentecost (Descent of the Holy Spirit).

The excellent condition of the frescoes (see Web Gallery of Art, http://www.wga.hu) allows for an examination of how Giotto used fundamental laws of perception and cognition that not only foretold major developments in art, but can be seen as reflecting and contributing to a world-view associated with a
sense of personal agency that would eventually replace the self-image of a pawn in a religious drama and victim of political mendacity.

First and foremost, Giotto was, for his time, uniquely skilled at producing a virtual three-dimensional space within a physical two-dimensional frame. The ability to create depth allowed him to develop a pictorial programme that manipulated spatial variables in such a way as to affect the perception of motion and time, and moral/religious judgements, all while effortlessly moving the spectator from one painted scene to the next. Many of the techniques that he used to gain realism, already apparent in his use of perspective, but now aimed, purposefully or not, at the spectator’s ability to empathize with the frescoed figures, involve what today we call embodiments, the idea that the operations of mind are influenced by the environment in the broadest sense, physical and cultural. Although embodiment has multiple meanings, implicit and explicit (e.g., Wilson, 2002), the basic notion is that the mind does not operate in a physical void. The real world, particularly as expressed in terms of space and time, has shaped the evolution of mind and, as such, affects its current operation.

Giotto’s intuitive grasp of the nature of perceptual embodiments can be seen in the connections between left-to-right movement and the significations of past, present and future time, and indirectly to the perceived direction of causality. These relationships are apparent not only in his completed frescoes, as will be shown below, but also in his preparations of the fresco surface prior to painting. From an analysis of several Arena Chapel frescoes (Tintori & Meiss, 1969), it appears that Giotto always began painting in the upper left corner of the fresco and continued to his right, covering as much of the surface above the figures as possible. The remaining areas, those that could be competed in a single day (giornata), also were sequenced with a distinct left-to-right preference that corresponded to the flow of narrative action and time within and between the frescoes.

Giotto’s rejection of Byzantine symbolic formulations for a new realism was expressed not only in the left-to-right dimension (laterality), but also in the up-down dimension (verticality). Without formal training in cognitive psychology, which centuries later might explain his success, Giotto applied a number of principles that encouraged the devout and often penitent churchgoer to move effortlessly from fresco to fresco, perceiving the narrative structure of the religious drama and yielding to spiritual veneration and the contemplation of redemption. Yet, at the same time, the spectator was induced to empathize with the credibly portrayed figures. As such, Giotto’s Paduan frescoes, which relied on observations of the real world, would have promoted a conscious recognition of personal agency that, however subtly, could impact on the development of Western culture, if for no other reason than that they blurred the distinction between sacred and profane. Giotto’s art undermined the mediaeval dualistic view, where publically available experience was undervalued, and the body was a mere instrument of the soul. His realism may well have served, albeit inadvertently, to reduce the social and psychological impact of religion and church.
This is not to suggest that Giotto was a conscious innovator of a “new art”, nor that he was the first to introduce the techniques for producing a psychologically coherent four-dimensional world on a surface where the paint brush can only move left or right and up or down. Giotto’s role in the tectonic shift derives from the merging of different means to create a seamlessly integrated pictorial narrative of a real world. The Arena Chapel provided Giotto with the ideal setting for displaying the products of an intelligence that, seemingly without effort, absorbed and used a basic understanding of how people perceive and relate to their visual environment.

THE VERTICAL DIMENSION OF SPACE

Embodiments of real world spatial variables into the operation/processes of mind are evident in the vertical dimension, particularly as expressed in language. Up and down are associated with the rising and setting of the sun. While the sun brings light (“the light of reason”) and warmth (“warm comfort”), its absence is accompanied by darkness (“to be kept in the dark”) and cold (“cold comfort”). More generally, the word “up” is associated with something good (“things are looking up”, “cheer up”, “climbing [up] the ladder of success”) and “down” with bad (“I am feeling down”, “down on one’s luck”, “looking down on someone”).

The vertical dimension is not only linked to the language of affect and evaluative judgements. Upward and downward movements of head and eyes are also tied to emotional valence. Looking upwards is often accompanied by expressions of positive affect, such as pleasant surprise, interest, general well-being. On the other hand, a downward cast of the eyes goes along with sadness, displeasure, a withdrawal from interaction with others. The embodied processes that relate to the vertical dimension of space appear to be limited to affect-involved activities. Such embodiments are most likely universal, as they are anchored in the regularities of nature, such as the rising and setting of the sun and the biological conditions for human survival, such as light and warmth.

As compared to the considerable amount of research on lateral spatial embodiments (see below) very little, with the exception of a few studies involving script that is read from top to bottom, is available for the vertical dimension. Readers of Mandarin Chinese tend to add a vertical component in assigning a direction to the flow of time (Fuhrman et al., 2011; Miles, Tan, Noble, Lumsden, & Macrae, 2011). This component is absent for readers of scripts that go from left-to-right (e.g., English, Italian) or right-to-left (e.g., Arabic, Hebrew), where there are only opposing lateral effects for the two language types (see below).

Giotto’s application of up-down embodiments

Although the narrative frescoes in the Arena Chapel are primarily ordered horizontally and relate to matters of space and time, it is the vertical dimension
that provides a schema for emotion and morality. However, the vertical and horizontal dimensions are not completely independent of each other. With the exception of Visitation and Betrayal by Judas, the narrative cycle frescoes are spatially organized as a descending clockwise spiral, beginning with God directing the angel Gabriel to make his celebrated proclamation to the Virgin Mary.

At the lowest level of the nave, the Virtues and Vices, ensconced in their painted niches, represent an unambiguous confrontation of good and evil. In the three registers above them, comprising the biblical narratives, the conflict between good and evil is acted out. Above them all, over the chancel arch on the east and west portal of the nave, the conflict is resolved. What God the Father, sitting high on the east wall had started, His Son, equally high on the west wall, has completed; Jesus in heaven dispenses justice, paradise for the virtuous and hell for the unrepentant sinners. Yet still higher, on the barrel-vaulted ceiling, with Father and Son having completed their earthly mission, there is a silent recapitulation, almost a memorial service for the major figures and events on the walls below. Centred on the western half of the ceiling, the Virgin Mary, who holds the Christ Child, is flanked by four Old Testament prophets. On the eastern side, Jesus holds an open book and offers a blessing. He is surrounded by three Old Testament prophets and John the Baptist. Notably, the frescoes on the ceiling are in the older Byzantine style, emblematic and iconic, rather than realistic, as in the narrative frescoes on the chapel walls.

Although the narrative cycle frescoes themselves, one above the other in the three registers, also invite comparisons (Alpatoff, 1947/1969, pp. 160–162; Smart, 1978, p. 52; Smith, 1978, p. 279), they have little to say about the relationship between the vertical dimension and affect or moral judgement. However, at the level of the dado, the embodied significance of the vertical dimension is evident. On the long walls to the side of and below the Last Judgment, Hope, on Jesus’ right, appropriately looks up to heaven, while Despair, on Jesus’ left, looks down.

THE LATERAL DIMENSION OF SPACE

As opposed to the universality of vertical embodiments, those of the lateral (left-right) dimension of space are clearly the result of cultural experience, namely the direction of script in reading and writing; such learned behaviours not only affect the organization of space, but also influence the perception of the direction in which time flows. Indeed, linguistic expressions of time are often associated with concrete concepts of space. Thus, past time maps on to that which is behind us and the future is in front of us; when a figure walks from left to right, the future is to his right and the past to his left. “I am looking forward to our meeting”; “Memory takes one back to the past”. The psycho-linguistic literature
is replete with reports that relate spatial dimensions to verbal expressions of past–future (e.g., Boroditsky, 2000; Johnson, 1987; Lakoff & Johnson, 1980; Miles, Nind, & Macrae, 2010).

Spatial words, often used to express duration of time, such as in “taking a long vacation” or “seeing a short film”, also give time itself a spatial quality. Furthermore, the “arrow of time” flies not only horizontally, but also in the same direction as the scan for reading text. Indeed, the direction of reading has far reaching effects on how many different events are represented mentally. In the West, past tense, small numbers and the cause of an action are embodied on the left, while the future, larger numbers and the object of an action are on the right. Similar but opposite effects are found in cultures that read from right to left, suggesting that learned reading habits are causally connected to these mental representations.

There is considerable empirical support for the effects of habitual reading direction on the perceived direction of movement and the apprehension of temporal position (past, present, future). As an example, when left-to-right reading English and right-to-left reading Arabic students were asked to draw an imaginary scene that contained two houses, one near and the other farther away, both groups drew the near house larger than the far house, and they drew the near house before drawing the far house. However, English-reading participants tended to draw the near house on the left side of the page and the far house on the right side of the page, while the Arabic-reading students displayed a slight right-side bias in placement of the near-house, and in placing the far-house to the left of the near-house (Vaid, Rhodes, Tosun, & Eslami, 2011).

In another study, German and Israeli preschoolers and adults listened to sentences in which the active agent was presented first and the recipient agent was presented second. For example, “Shirley gave John the umbrella”. In other sentences, the recipient was presented first and the active agent was presented second, as in “John received the umbrella from Shirley”. After listening to each sentence, the participants completed one of two tasks: (1) arranging pictures of the active and passive figures so that they represented the sentences that had been heard; (2) drawing the contents of the sentences. The young children, whether German or Israeli, did not exhibit any directional bias. The adults, on the other hand, showed language-linked biases. For left-to-right reading Germans, the behaviours described in the sentences were depicted as flowing from left to right, from the active component to the passive one; for the right-to-left reading Israelis, the direction was reversed (Dobel, Diesendruck, & Bolte, 2007; also see, Fagard & Dahmen, 2003).

Left-to-right readers also conceptualize time as moving from left to right, while right-to-left readers conceive time as flowing from right to left. In one of the earliest studies on this topic, Tversky, Kugelmass, and Winter (1991) asked Hebrew-, Arab- and English-speaking children to place stickers on a paper to represent several temporally ordered events, such as breakfast, lunch and dinner.
In general, the meals were spatially ordered in accord with the culturally determined direction of reading and writing. Thus, English participants placed the stickers from left to right—breakfast, lunch, dinner; their Arab counterparts used the same order, but the placement was from right to left. The Hebrew-speaking children had a similar right to left order as the Arab children, but less pronounced, probably because of a greater familiarity with English. Numerous studies have confirmed these findings (for a review, see Tversky, 2011). As already noted, the effects of written language on the perception of the direction of time flow can also be seen with readers of Mandarin Chinese (read from top to bottom), for whom the flow of time has a vertical component (Fuhrman et al., 2011; Miles et al., 2011).

Although the older literature suggests that extensive experience with a particular script is required to affect the perceived direction of the flow of time, more recent studies indicate that as little as five minutes exposure to mirror-reversed orthography or to 90° rotations, to the left or to the right, result in corresponding changes in the mental timeline (Casasanto & Bottini, 2014).

Given that directional biases derived from the habitual, language-determined direction of scanning script contribute to the organization of pictorial space and time and to the direction of causality, it is not surprising that reading direction is also associated with aesthetic preference. In the West, paintings that can be “read” from left to right are preferred to those that can be read from right to left (e.g., Gaffron, 1950). Similarly, images which move from left to right are preferred to those that move in the opposite direction (e.g., Freimuth & Wapner, 1979). Contrary to earlier reports that aesthetic preference was influenced by neural organization, specifically brain-hemisphere specialization, recent experiments have established that such partialities are, indeed, affected by the habitual direction of reading script. Left-to-right readers (e.g., French, Italian, Spanish, English) have preferences for images with a left-to-right directionality, while right-to-left readers (e.g., Arabic, Iranian) exhibit preferences in the opposite direction (Chokron & De Agostini, 2000; Gonzalez, 2012; Heath, Mahmasanni, Rouhana, & Naddif, 2005; Maass, Suitner, & Nadhmi, 2014; Román, El Fahi, & Santiago, 2013).

Giotto’s application of left-to-right embodiments

The left-to-right sequence, historical continuity and the fluidity of spectator movement

With but few exceptions, Giotto’s narrative frescoes lend themselves to a left-to-right reading (see below), providing the viewer with continuity and coherence by positioning the frescoes on the chapel walls in the spatial order that was generally believed to have occurred in historical time. Indeed, Giotto’s contemporaries, irrespective of class and literacy, would have been familiar with the temporal order of central New Testament episodes, as well as apocryphal
stories retold from collections such as de Voragine’s *The Golden Legend* (c. 1275). Thus, as just one example, where time moves from left to right, the *Kiss of Judas* is immediately to the left of *Jesus before Caiaphas*. In the former, Judas identifies Jesus to the soldiers; in the latter, the captured Jesus is brought before Caiaphas for judgement. Beyond simply matching the spatial and temporal orders, Giotto used several other techniques to usher the spectator from one painting to the next, the most salient of which was inducing the perception that figures moved from left-to-right not only within paintings but also between them.

The most important cue for perceiving direction of movement of an otherwise static image is the one that we use in everyday activities. A person who moves in front of us from left to right is represented on our retina in right profile with eyes pointed in the direction of movement. As such, the observer’s attention is captured by the implicitly moving figure and moves with it to the right; the allocation of attention to the right has been primed by the implicit rightward motion of the figure. When a Giotto figure is seen as moving across a fresco, it almost always will be going from left to right. As an example, in *Joachim Driven from the Temple*, the priest pushes Joachim to the viewer’s right, from where he reappears on the left side of the adjacent fresco in *Joachim Joins the Shepherds*. Similar left-to-right movements can be seen in *Sacrifice of Joachim*, where Joseph approaches the altar from the left, and in *Meeting at the Golden Gate*, where he again enters the scene from the left and moves towards Anna who awaits him. In the *Virgin’s Wedding Procession*, the entire wedding entourage moves from left to right towards Mary’s home and the musicians who stand in front of it. Additional instances include, but are not limited to, the *Betrayal by Judas, Adoration of the Magi, Presentation of Jesus in the Temple, Raising of Lazarus* and *Entry into Jerusalem*.

An inspection of all of the narrative frescoes ([http://www.wga.hu](http://www.wga.hu)) indicates that of the 36 frescoes that comprise the four narrative cycles, 25 provide examples of the left-to-right directionality (e.g., see above), 8 are indeterminate (e.g., *Nativity, Last Supper* and *Pentecost*) and 3 are counter-examples (*Annunciation to St. Anna, Mocking of Christ, Marriage Feast at Cana*). In the three counter-examples, the right-to-left directionality is relatively weak as compared to the left-to-right examples.

In keeping with the general left-to-right trajectory, people typically enter the picture from the left side. On the other hand, when a figure is seen as exiting, it is at the right side of the picture. Thus, in *Resurrection (Noli me tangere)*, Christ, situated at the extreme right of the picture, is taking leave of Mary Magdalene and, indeed, of this world.

The left-to-right movement provides links, either to the previous fresco from which the figures have emerged (from the left), or to the following fresco into which they are about to enter (to the right) or to both. To make these directional cues even more salient, Giotto deployed minor characters who enter or exit from
the margins of the frescoes, with only portions of their bodies visible; the unseen parts implicitly lie outside the picture frame, as in the shepherd in *Meeting at the Golden Gate*, or the attendant in the *Nativity* who hands the swaddled infant to Mary. The same technique can be seen with figures within larger groups, such as in *Marriage of the Virgin, Virgin’s Wedding Procession* and *Baptism of Christ*.

As would be expected, figures that enter scenes from the left orient themselves to events that occur towards the centre of the painting. Departing figures, characteristically on the right side of the picture, typically attend to events that are even farther to the right and beyond the frame of the fresco, leaving behind them, unattended, the remaining fresco activities. Giotto used departures to great effect by creating a conflict between leaving and staying, as illustrated in *Road to Calvary*, where the tension between stop and go is expressed by the two otherwise undistinguished characters that precede Jesus. The one at the farthest right, in right profile, is already half way out of the scene. The second figure, closer to Jesus, but still at the far right, is visibly of two minds. Although his forward motion would remove him from the scene, he nevertheless turns his head to observe the tormented Jesus. The *contrapposto*, where the figure is posed asymmetrically, shoulders and hips turning in different spatial planes, reappears in the *Resurrection*, where Christ is torn between Mary Magdalene’s plea that He stay and the higher calling to ascend to heaven. The pose is all the more powerful because it is self-conscious, as would befit a grand theatrical departure.

The above descriptions of left-to-right movements have as their point of reference the spectator who is looking at the fresco. However, when the figure of Jesus is presented hieratically, as in the *Last Judgment*, Giotto replaces the primacy of the observer-based left-to-right orientation with one that is centred on Jesus. Now, what is on Jesus’ right is on the spectator’s left. Thus, in the case of the spectator-centred orientation, Giotto used the visual stimuli of the real world to represent actions and events. However, when Jesus is portrayed frontally, left and right become significant from His point of view, thereby breaking the link between spectator and veridical perception and, instead, forging one between the spectator and the holiest of church figures. When Jesus becomes a religious emblem, as opposed to the more human Jesus in the narrative frescoes, the thrust towards realism is weakened.

**Direction of time within and between frescoes**

Giotto was not only a master at producing perceived movement of a figure or its cessation, but he also recognized that the direction movement, or its absence, had significance for mentally representing and differentiating between past, present and future. He consistently linked space and time within frescoes as well as between frescoes, such that what is behind the moving figure (to the left) was and what is in front of the figure (to the right) will be. Thus, as noted, the
sequencing of the narrative frescoes in the chapel, in keeping with the historical
temporal order of events, is from left to right, as are the sins of the past to the
redemptions of the future. Similarly, left and right movements within the frescoes
refer to past and future events. As already described, entries into the fresco are
from the left (from a place in the past to the present) and exits are to the right
(from the present place to a future place).

Left-to-right movements and their implications for temporal locus (past,
present or future) can be decomposed even more finely. When a figure in the left
half of a scene looks to the right, it directs the spectator’s attention to events or
actions that are further to the right; the default mode for most of the frescoes. For
instance, the angel in Joachim’s Dream flies in from the left in order to deliver a
message to Joachim. However, if a figure’s rightward gaze is delivered from the
right portion of the scene, the character appears to be unconcerned with the
activities behind him. Instead, the gaze alludes to some event in the future, often
in the adjacent fresco, as in moving from Joachim Driven from the Temple to
Joachim among the Shepherds, but sometimes to an event yet to appear. Thus,
the darkly shrouded woman in Meeting at the Golden Gate, in contrast to the
other figures in the fresco, looks to the right, away from the ongoing action and
towards the future, perhaps warning of the betrayal and crucifixion of Jesus.

As opposed to the rightward gaze that points to the future, past events
are signified by a leftward gaze, usually from a figure on the right side of the scene.
Thus, the angel in Presentation of Jesus in the Temple and in Flight into Egypt
appears on the right and looks back to the left. In addition to a guardian function,
the angels often allude to Gabriel in the Annunciation to Mary and they confirm
the miraculous birth of Jesus, an event that happened in the past, in story and in
fresco location. While these examples suggest a turning to the past, in Sacrifice
of Joachim the angel stands on the far right side of the scene, and by looking to
the left, he acknowledges that the depicted sacrifice had been accepted.

Similarly, minor figures that draw attention to and provide commentary on the
main action are on the far right of the picture. Typically, the figures are in pairs,
one conversing with the other and glancing back to the left. They are discussing
something that has just occurred (past), perhaps with implications for the future
(e.g., Presentation of the Virgin in the Temple, Cleansing of the Temple, Betrayal
by Judas).

In Jesus before Caiaphas, where Christ enters the room from the left, He
looks back over his shoulder rather than at Caiaphas in front of him. His eyes are
averted to the right (spectator’s left), suggesting a reflection on times past, to the
events that led to His current plight. Similarly, the spectator also is directed back
to those stories in the preceding frescoes.

In Road to Calvary, Jesus turns his head and eyes in a manner almost identical
to that in Jesus before Caiaphas. In the former, however, when Jesus turns to the
past, it is associated with ambivalent emotions, to the recent abuses and cruelty,
but also to His mother who stands at the far left. The scene is repeated in the
Resurrection, but now the Virgin Mary is replaced with Mary Magdalene. Again, there is a conflict between going away and staying. In Road to Calvary, the conflict is resolved by the centurions who forcibly prod Jesus towards His crucifixion. In the Resurrection, however, it is Jesus who chooses between the entreaties of Mary Magdalene and His future in heaven as the redeeming judge. By creating parallel vectors to the past, one for Jesus in the fresco and the other for the spectators observing Him, Giotto enhanced the shared emotional experience between Jesus and His viewers.

The relationships between left and right and the direction of time go beyond the locations of individuals in the fresco and the paths of their gazes. Past and future, old and new, also are signified by the left and right positions of objects. Thus, in Massacre of the Innocents, the scene is framed on the left by Herod’s palace, or some other public building of the old order, and on the right by a basilica or baptistry, representing the new order. Even more subtly, Giotto used the cross of the crucifixion and the formations of rocks for the same purpose. In Road to Calvary, the left arm of the cross points downwards, behind Jesus, to the past. In contrast, the right arm of the cross in front of Jesus points upwards towards where Jesus is heading, to the crucifixion (the very next fresco), to death and to resurrection. In the Lamentation, the rock formation has a similar configuration, going from lower-left to upper-right, and also leading to the next fresco in the series, the Resurrection.

Stopping time. Just as Giotto appreciated that pictorial time proceeds from left to right (at least for his audience), with the past behind, and the future ahead, he also knew how to protract the perception of passing time and even to stop it. Furthermore, he understood that the devices used for these purposes increased emotional impact. Giotto’s technique for freezing time was simple. If left-to-right movement evokes a perception of time moving forward, and right-to-left signifies a reflection on the past, then a stationary figure should produce a sense of here and now, the present. As already described, Giotto suspended time by using the classical contrapposto figure, where motion is stopped by turning the torso and head in opposing directions, as in Road to Calvary and Resurrection (see above).

Movement and time are also frozen in the Lamentation, as the awe-struck mourners’ crowd around Jesus’ lifeless body. The immobility is reinforced by forcefully directing the viewer’s attention to the lower left corner where the Virgin Mother embraces her motionless Son. Mary Magdalene, as in the immediately preceding Crucifixion, remains disconsolate at Jesus’ feet. In the very next fresco, Resurrection, Jesus is once again alive. Mary Magdalene, awoken from her grief, pleads with Jesus to stay. But Jesus, now buoyantly erect on the right side of the fresco, seems about to pirouette out of the scene and to take flight into the next one, the Ascension, where He will swoop upward into the heavens. Here, Mary Magdalene and all of the other witnesses turn their gaze upwards to the ascending Jesus; awe and reverence have replaced grief and disappointment.
Giotto also brought time to a temporary halt by focusing attention on pairs of stationary figures, usually centrally located, who face each other, left-to-right annulling right-to-left. In placing two figures close together, as in *Meeting at the Golden Gate* and *Pact of Judas*, he intensified an already emotional event, albeit in these examples in opposing directions. In *Meeting at the Golden Gate*, virtue has been rewarded. Joachim, who had been expelled from the Temple for being unable to father a child, is reunited with his wife Anna, who he kisses with the knowledge that she will bear him a daughter. The viewer is gratified and relieved. In opposition, when Judas kisses Jesus in *Pact of Judas*, the spectator is repulsed by the momentary victory of evil over good.

In a more speculative example of time brought to a standstill, Prudence, one of Giotto’s seven Virtues, sits behind a desk. In right profile, she is seen looking into a mirror. Her rightward gaze points to the future, but the left-facing mirror image reveals her past. With an open book in front of her, and pen in hand, one might think that the namesake of cautious deliberation is composing her thoughts, reviewing what went before to reveal what lies ahead.

*Left and right as signifiers of moral worth.* As Giotto amply illustrated, leftward and rightward directions not only affect perceptions of movement and time, but also they allude to moral status. In the New Testament, the left is associated with evil, sin, the Old Testament, worldliness and non-belief in the Christian god, while the right is associated with righteousness, spirituality, and accepting the truth of the New Testament (e.g., Fabbro, 1994). Giotto and his contemporaries spectacularly displayed the connection between left-right and evil-good in the numerous Last judgements over the main portals on the west-side of naves, where Jesus with His left hand sent the wicked to hell, and with His right hand, the virtuous to heaven.

Giotto also linked the left-right denotation of evil-good in the *Last Judgment* with the placement of the Vices on Jesus’ left and the Virtues on His right. As the parishioner exits the chapel and faces the *Last Judgment*, Despair, looking downwards, expresses the final emotion before being consigned to eternal damnation, while her opposite, Hope, faces upwards, anticipating the election to paradise (Smith, 1978).

**SUMMARY AND CONCLUSIONS**

Giotto’s Arena Chapel frescoes provide a rich source of psychological embodiments, particularly in regard to the cardinal positions of two-dimensional space, vertical and horizontal. Giotto’s vigorous application of the left-to-right dynamic, a result of reading Latin and the relatively new Italian vernacular (earlier scripts were dominated by right-to-left Aramaic, Hebrew and later Arabic) integrated the individual fresco with the global narrative programme,
moving spectators fluidly through the chapel while helping them to identify, emotionally and cognitively, with significant religious characters. While the learned habits of reading imposed constraints on the perceived direction of the flow of time, epochal aspects (past, present and future) and the path of causality, the physical environment and the requirements of human biology afforded a very different set of embodiments, ones concerned with affect and morality.

The associations between habitual reading direction, spatial laterality effects in painting (such as the direction of time and causality) and aesthetic preference may have a common basis. Reading script requires a series of fixations during which time relevant information is acquired. The reading process can be described as a self-reinforcing system such that each lateral scan (or vertical for some Asiatic languages) is reinforced when the information at a current fixation point is compatible with that from the previous fixation point (for example, if the letter sequence ARE is extracted from the current fixation, while the prior fixation yielded YOU, the directional movement corresponding to the reading of YOU ARE, in this case left-to-right would be reinforced). This, in turn, leads to a system prediction of what the next fixation will bring—which, if confirmed, would again reinforce the left-to-right movement. In short, each fixation reinforces the previous one and at the same time provides the prediction term for the assessment of the next one. Given this forward moving action, one might expect that the shape of the functionally active area surrounding the fixation point would not be symmetrical. Indeed, it is elongated in the direction of the scan, such that more information is picked up in front of the fixation point than behind it. Thus, for English readers, the perceptual span is biased to the right, and for Arabic readers to the left (Jordan et al., 2014).

The enormous number of directional scans involved in reading, whether in populations that read from left-to-right or right-to-left, provides a repetition of sequential events that at once confirm the past and predict the future. It is no wonder, that habitual reading direction is associated with conspicuous lateral spatial biases in a wide range of other behaviours.

Giotto’s art, in its thrust towards realism, captured the codes of embodiment that encouraged viewers to perceive biblical figures as human incarnations rather than as mystical other-worldly icons. By creating a painted world based on observation, he introduced the perceptual, emotional and cognitive embodiments of actions and thoughts that could prompt the spectator to empathize with the pictured figures and their activities. Giotto’s success in affecting behaviour lay not only in his skills in representing space, figural volume, depth of field and movement, but also in his ability to harmonize spatial, temporal and moral factors, creating a psychologically seamless narrative that resonated with the mediaeval spectators and raised them to new levels of self-consciousness.

As such, Giotto’s Arena Chapel frescoes did for realism and humanism what the Franciscans advocated in religious practice and what the great poets of that time did in verse. Not only were his lessons taken up by many artists who
followed him, but more generally, if a picture is worth a thousand words, then a largely illiterate population was exposed, however subtly, to the new currents of empiricism and science; observation was becoming a primary source of information, and human character, infused with a new sense of self-agency and empowerment, was encroaching on a world-view dominated by dogma and intimidation.

Had Giotto been presciently knowledgeable of modern cognitive psychology, he might have taken satisfaction in knowing that the intuitions expressed in his art were supported by evidence from the laboratory. In particular, he might have appreciated the recent discovery of mirror neurons, brain cells that are activated when an organism executes a particular act, but which also fire when the same behaviour executed by someone else is merely observed. Although still controversial, mirror neurons have been credited with being involved in a number of behavioural phenomena, including imitation, empathy, understanding the intentions of others (e.g., Iacobini, 2009), and even in aesthetic experience (Freedberg & Gallese, 2007), all amply illustrated in Giotto’s art. If valid, mirror neurons, or any mechanism for automatic imitation (e.g., Heyes, 2011), would provide a potent framework for illuminating the processes underlying the cognitive and emotional effects produced by Giotto’s frescoes, and understanding how Giotto’s new realism influenced a reallocation of psychological resources that prepared the way for modernism, contributions for which he has yet to be recognized.

Given the correspondence between the findings of modern cognitive psychologists and their expression in Giotto’s art, one might ask whether at least some of the time spent in the laboratory might have been better used to study late mediaeval art. There is much that we have been discovering by experiment that could have been learned, as Giotto evidently did, by observation. As psychology might inform art, so too might art inform psychology, at least as a source of testable hypotheses.

REFERENCES


