The Cleaning of Acrylic Paint Surfaces 3 London workshop

Background

I should start this review with a disclaimer that it is thoroughly disconcerting to write *anything* whatsoever about a subject to which so many smart people have dedicated so much time and thought. The existence of this review is due to a fit of acquiescence that took place when Chris Stavroudis caught me off-guard as I arrived at the workshop on the first morning and said "You *are* going to write a review for the *WAAC Newsletter*, right?" Accordingly, all errors, generalizations, or omissions in my review are attributable to my lack of expertise or comprehension, rather than any shortcomings of the instructors.

In early July, eighteen conservators from eleven countries gathered together with four instructors at the Tate conservation department in London to learn about, undertake tests on, and discuss the cleaning of acrylic painted surfaces. Organized by the Getty Conservation Institute, Cleaning of Acrylic Painted Surfaces 3 (CAPS3) followed two invitation-only CAPS colloquia in Los Angeles (2009) and New York (2011).

The previous meetings convened experts in the conservation of contemporary paintings to brainstorm on issues surrounding the cleaning of modern paints, with particular emphasis on acrylics which are now so firmly established both on the artist's palette and for other commercial applications. There was a great response to the posting of the 2012 CAPS workshop, with the number of applicants far exceeding the number of available places - an imbalance that indicates how eagerly conservators wish to learn more about new developments in this area of our work. For the first time, in addition to paintings conservators, CAPS 3 included conservators from allied fields who also encounter acrylic paints.

Hosted and taught by Tate's Dr. Bronwyn Ormsby, Dr. Tom Learner from the Getty Conservation Institute, Professor Richard Wolbers of the University of Delaware, and conservator Chris Stavroudis, and organized by the instructors and Tram Vo of the GCI, the workshop presented the remarkable body of new material that has been developed in this arena in recent years. The workshop instructors represent several of the institutions (and individuals) that have invested considerable resources in this research.

In preparation for the meeting, the attendees digested a weighty list of background reading before arriving at the Tate conservation facility in Tate Britain on July 3rd (with the help, in some of our cases of many hours of jet-lag induced insomnia). While it isn't possible to credit fully the teams of scientists and conservators who were mentioned by the instructors during this short review, it should be made clear that the scholars mentioned below, and many more who have undertaken studies in this field, were given full and proper credit by the instructors throughout the workshop.

Introduction to acrylic paint studies

During the first morning session, Tom Learner delivered a comprehensive review of the background that lead to the CAPS series, first of all addressing the issue of need. The flourish of work in this area over the past two decades had been prompted by the proliferation of materials available to artists and works of art that were beginning to age. There was also a general concern, despite the availability of commercial technical literature, about the relative paucity of information about acrylics within conservation training and in our professional literature. As Tate director Nicholas Serota stated in the 2007 joint Axa Art Insurance/Tate publication, *Caring for Acrylics:*

"The need to explore conservation issues surrounding acrylic paints has recently become more pressing as early acrylic works are now approaching fifty years old. Despite the frequent occurrence of acrylic paint in collections, conservators have access to very little information on how acrylic paints might alter with age, or how they are affected by conservation treatments such as surface cleaning."

To these points about what *happens* to acrylic paints over time or because of conservation problems, we might add a lack of widespread appreciation within our field for exactly what acrylics *are*.

Because of this need for information, a project entitled Modern Paints Uncovered (MPU) was initiated in 2002. The objectives were to improve analytical methods so that there might be better understanding of the physical properties and surface characteristics of modern paints and to examine the effects of cleaning. As would later be the case with CAPS, the organizers sought to make treatment and the consequences of treatment central parts of the research. MPU was a collaboration between Tate, the Getty Conservation Institute, and the National Gallery of Art (Washington, DC), and it culminated in a landmark conference in London in 2006 that was presented and attended by artists, paint manufacturers, scientists, curators, and conservators.

Following the MPU conference something of a sense, if not of inertia then, perhaps, one of discomfiture, descended around the issue of surface cleaning acrylic paintings. This concern centered on the complex of technical and ethical issues pertaining to the removal of surface soiling and the range of constituents within acrylic paint that may find their way out of the bulk paint film and onto the surface.

Despite the apparent impasse, what was clear was that it would be necessary for us to better understand and control dirt removal from acrylics, and for us to assess potential short- or long-term harmful consequences to the paint from cleaning. It was also clear that ongoing studies would need to continue to negotiate a delicate balance of scientific investigation, ethical concern about the removal of paint film components, and empirical evaluation and documentation of test treatments.

A space-time continuum of pH and conductivity *by Nicholas Dorman*

The desire to move ahead using the particular format of the CAPS series, rather than simply the dissemination of scientific findings, was in good measure determined by the tenet that conservators, as well as their scientist colleagues must be closely involved in the research. In this way, there might be the best chance for the field to build viable methodologies based on the combined achievements of scientific testing and practical experience. As Tom stated unequivocally at the outset of the workshop, "Conservation has a craft element, and this should proceed together with science."

Other key concerns that emerged from the MPU and earlier CAPS colloquia included identifying how best to disseminate findings, practical treatment issues, preventive conservation issues, ethical questions, and a theoretical framework for cleaning as well as the need for an open and collegial forum for sharing ideas and experiences.

Acrylic paint basics

Tom went on to discuss acrylic paint basics, from the introduction of Magna acrylic solution paints in the late 1940s to the acrylic emulsion paints that emerged as artist colors in the 1960s. He citing examples of specific artists and their reasons for being attracted to these new paints, from rapid drying to their permanence, the pleasant working properties of water-borne paints, and their ease of use.

The molecular structure of the acrylic polymer components were discussed along with the effect of the particular proportion of monomers (and additives) in determining the glass transition (Tg) temperature that dictates how viscous or tacky a paint film is at a given temperature. For modern artists' acrylics, the combination of monomers is balanced to provide paint with a Tg that is set high enough to avoid tackiness and low enough to avoid brittleness at normal room temperatures.

Next, the role of additives within the liquid paint was discussed. These include surfactants to keep the polymer components suspended in solution, pH buffers to maintain optimal conditions for all components, anti-foaming agents to prevent bubbles, thickeners for that nice buttery (Smart Balancey?) texture, freeze-thaw agents, coalescing solvents to help with film formation, biocides, pigment dispersants, and wetting agents to prevent clumps and precipitation and to make sure the original preparation is thoroughly incorporated within the water phase of the paint.

The work of many of these components has already been accomplished once the paint film dries. How much remains and where it resides within the dried film, however, beomes an interesting issue. Examination of dried acrylic films has revealed that a less than homogeneous acrylic film may be formed during drying, with some of these additives becoming pushed into pockets within the film from which they can subsequently move out onto the dried paint surface when conditions permit.

Attendees were introduced to recent research findings with an account of how acrylic emulsion (and solution) paints behave when exposed to water, solvents, temperature and relative humidity changes, and soiling. Tom discussed aging and mechanical properties of acrylic emulsion paints and grounds and described tests that were undertaken using dynamic mechanical testing, immersion, and light and heat aging that had helped researchers to explore the physical and chemical properties of the films and their aging characteristics.

So at this early point in the workshop, a picture emerged of acrylic as a paint that is durable and flexible within its comfort zone but one that may crack, swell, or imbibe dirt or blister when pushed, and one that contains an inherent ethical and practical challenge in the form of surfactants. We gained a clear sense that preservation of acrylic paint films requires better-defined parameters for both preventive care and treatment.

What also became apparent was one of the most bewildering facts for the conservator seeking a framework for treating paintings: the heterogeneity of acrylic paints. There may be considerable differences in film softness or surfactant levels from color to color and, furthermore, what is ostensibly the same color but from different manufacturers, may exhibit very different responses to cleaning solutions or environmental conditions.

Cleaning chemistry

In the next session, Chris Stavroudis explained the chemistry of liquid cleaning. His talk introduced the concepts of buffers, conductivity, and ionic strength, with which attendees of his Modular Cleaning Program workshops (and readers of this *Newsletter*) will be familiar. For acrylic cleaning, the emphasis was on aqueous systems and chelating agents, buffers, and surfactants, each having important roles to play in the various cleaning solutions which we tested throughout the week.

Chris developed the notion of reducing paint swelling by discrete methods, and he described how conservators might use emulsions to control the action of water used for cleaning. In addition to conventional emulsions, Chris discussed microemulsions where the water phase is incorporated much more intimately with the solvent phase. He also discussed the polymeric emulsifier Pemulen TR2, a material that allows the simple formulation of oil in water emulsions without the need of a surfactant.

For both the Pemulen-based emulsions and silicone microemulsions, he noted that the aqueous phase could be built with the MCP. (See *WAAC Newsletter*, Vol.34, No.2, May 2012 and Vol.32, No.3, September 2010 for articles by Chris, Richard, and others about Pemulen.)

Tests on the paint samples

During the ensuing practical session, attendees studied acrylic color samples on prepared canvas pieces. This examination revealed the great variety among the colors; how various colors from a single manufacturer displayed different stiffness, matteness, gloss, bubbles, or crisp or dull ridges at the edge of the samples. Some samples were perceptibly "greasy" with surface surfactant. The test swatches allowed us to see for ourselves the fact that different manufacturers incorporated varying ingredients into their colors so, for example, the cadmium orange of one manufacturer displayed quite different surface characteristics from the cadmium orange produced by another company.

The first tests undertaken by the workshop attendees were simple swelling tests with drops of water, buffered water, carbonated water, etc.

After testing surface conductivity of each paint sample using little slithers of agarose gel and a conductivity meter, drops of the range of test solutions were then placed on the surface of the samples and a number of phenomena were observed.

The manner in which a drop spread on the surface or held its form was a helpful indicator of the presence of surfactant on the surface. We were also eager to see which test areas swelled most. Many colors were affected by swelling; the 20mS/cm (20,000µS/cm), pH6 water swelled most colors less than other solutions.

Although, during an actual treatment, the action of rolling a swab over a painted surface is quite different from letting a drop sit on a paint surface for a minute, the marked response that some films exhibited made an impact on many of us. In addition to displacing surface surfactants, the drops of water caused the test area on some films to form quite a little dome of swollen paint, sometimes with sharp ridges at the edges of the drop. In some instances the films recovered to become flat and even, in other cases the test locations remained visible as lines where the edge of the drop had been or as a slight change in the gloss level.

Research into the effects of cleaning

On the second day, Bronwyn Ormsby complemented these initial empirical observations with a detailed consideration of recent research into the effects of wet-cleaning treatments on acrylic paints.

The debate about the removal of original surfactant components had caused concern among some delegates at the 2006 MPU conference. (Much of the work described here can be found in the Proceedings from the MPU conference, Getty Publications.) Accordingly, researchers have continued to look very closely at a series of questions relating to extraction: what comes out of the bulk of the dried acrylic paint film and what from the paint surface during cleaning? How much of it comes out? How quickly is it extracted? Does removal of materials at the surface disturb the distribution and equilibrium of materials, and trigger more migration of components?

Researchers have continued to deploy, test, and evaluate by analytical means different extraction techniques, including full immersion for various durations and swabbing, in order to refine our understanding of this process. Bronwyn and Jaap Boon's electrospray ionization mass spectrometry studies confirmed the presence of specific surfactants on the surface of paintings. Other studies by Greg Smith, Stefan Zumbuehl, Rebecca Ploeger, Paul Whitmore, and their co-authors were reviewed in terms of their contribution to our understanding of how materials move through acrylic films and what comes out of acrylic paints subjected to water or solvent washing. Some of their findings are discussed here.

As evidenced by our test protocols the previous day, swelling is a critical area of recent research. At the GCI, dynamic mechanical analysis has been deployed to determine swelling responses for various paints. Findings indicate that the propensity for swelling relates to brand, pH, and, to some extent, the pigment or colorant present.

Separate stress strain tests by Rebecca Ploeger and others, following immersion and drying of samples, showed that while acrylic samples immersed for 24 hours in water did break sooner than the control in stress/strain tests, those immersed for 1 minute did not break appreciably sooner than control samples and those subjected to swabbing alone were close to the control in terms of resilience.

Analysis of submerged samples indicated that their polymer chains were more densely packed following immersion. Such changes were not seen in swabbed samples in Rebecca's tests, although severe protracted changes in RH (e.g. 10%RH) induced comparable polymer densification to that seen following 24 hour immersion.

The mechanism by which surfactant moves to a paint surface was described along with patterns of occurrence; earlier paint formulations and organic pigments both appear to be relatively surfactant rich.

Clearly, the technique of paint application and thickness of the film also exert an effect on what eventually leaches out of the paint, as do other factors such as conservation treatment, film age, and environment.

Surfactant from bulk paint films can be measured on the surface within days of application, but it isn't always there. Some brands are surfactant-rich very quickly. In other brands there is initially no surface accumulation but it emerges to cover the surface over time.

Bronwyn gave an account of tests intended to determine the effect of water on paint films and surfactant at different conductivity levels and the session concluded with a summary of the effects of cleaning.

Again, we were guided to think about those conditions under which acrylics are most stable. While they may be vulnerable to swelling with water, swelling may be avoided or controlled somewhat by combining aqueous cleaners with aliphatic hydrocarbon solvents or by setting aqueous systems at pH 5-6.0 (though, again, we were reminded that different paints will respond differently).

A caveat was also introduced here. Even if we decide that a surfactant-rich dirt layer should come off a paint surface, it will likely return at some point; while swabbing for a minute cleans surfactant from the surface, it does not seem to remove any from the bulk film.

New cleaning options

In the next section, we were introduced to new cleaning options being developed by Dow Chemicals together with the GCI and Tate. The test methodology involved creating artificial dirt and evaluating cleaning efficacy using both conventional manual cleaning tests and a robotic instrument for industrial applications, known as a High Throughput Cleaning Device.

The robotic system enabled specific assessment of cleaning efficacy so that, for example, deionized water might be determined to achieve 13% cleaning of a sample whereas the addition of Triammonium Citrate and TRITON™ XL-80N yielded 84% dirt removal. Aqueous and mineral spirit solvent systems were tested along with surfactants including, in the second generation of tests, "green" products, such as Ecosurf EH 3, 6, and 9 (Dow specialty ethoxylate surfactants that are fast-wetting, low odor, low foaming, and biodegradeable). (See article by Chris Stavroudis, pp. 24 - 28.)

By varying components and pH levels different effects were achieved, and the tests resulted in the tailoring by Dow of a series of clear, stable microemulsions that combine hydrocarbon solvents, water, surfactants, and other constituents in various combinations and proportions. The microemulsions proved in both robotic and conventional testing to be nearly as good as water at cleaning without water's downside of swelling, and much more effective cleaners than mineral spirits alone. In effect, they are a mineral spirit-based system that can encapsulate water and surfactant, effectively targeting dirt while simultaneously forestalling swelling of paint.

Naturally, a new system such as this is not without challenges. Early tests indicate that critical issues for conservators, such as the stability of the emulsion, controllability during use, clearing, and speed of cleaning action require further study and refinement. In their current form, the particular alcohol content, added as a cosolvent, in some of these microemulsions also makes some of them smell quite powerfully.

Richard Wolber's presentation on the second afternoon developed the theme of controlling swelling during cleaning. He followed on from the earlier discussion by underlining the notion that aliphatic hydrocarbons might form a promising component within systems for cleaning acrylic paints. While they themselves effect only moderate cleaning action on most acrylics, they also cause minimal disruption or extraction of the paint film.

For effective cleaning, however, it seems essential to combine an aqueous component with the aliphatic hydrocarbon in the cleaning system. Here Richard proposed that even if we can't completely mitigate the potential for extraction and disruption that comes with the choice of water for cleaning, we can nevertheless modify the pH, conductivity, and specific ion effects so that the cleaning solution has as benign an effect on the paint surface as possible, while still remaining an effective cleaner.

To illustrate this point about manipulating the action of water, Richard demonstrated how conductivity of the cleaning solution can predict the swelling effect of a solution, since a solution with low conductivity results in water moving into the paint film due to osmotic pressure (and, potentially, the action of components such as the Triton surfactant in the film). To prevent this water movement, the osmotic pressure can be adjusted by adding salts to the cleaning solution.

Richard has determined that, in general, the isotonic level for a safe cleaning solution will be approximately ten times the conductivity of the paint surface. However, the character of the ions in the solution also matters. Different salts in the cleaning solution may yield different amounts of swelling on different colors from different manufacturers. (We observed little swelling in a cadmium yellow sample the previous day with a cleaning solution containing sodium chloride but considerable swelling of the same sample with a solution at the same conductivity level containing sodium sulphate.)

Microemulsions were again discussed at this point including the various formulations: classic cosolvent emulsions and surfactant only emulsions. Richard provided an account of biodegradeable surfactants and two siloxane-based solvents that are even less polar than aliphatic hydrocarbons. The microemulsions enable the user to retain the cleaning properties of the constituents of the emulsion while controlling the amount of water or surfactant that actually reaches the paint surface.

Evaluating the tests

Thursday commenced with a review of the test results with Richard.

There was consensus among the group that the Dow microemulsions worked very rapidly. The results also corroborated the notion that the closer you get to pure water, the greater the risk of swelling, with those solutions containing most water causing the most rapid swelling. In general, it was extremely interesting to have the opportunity to test the panoply of cleaning solutions provided. As Richard stated during the tests, "there will not be a single answer to these cleaning problems. Generally speaking, the less water, the less aggressive the system, and the less solvent (or the less polar the solvent), the less aggressive the system."

Beyond these facts, even this short round of testing confirmed that there are many solvent/water/surfactant choices that can be made. An interesting observation from several conservators was made regarding the efficacy of saliva in the tests, and Richard confirmed that the water, pH level, and conductivity of saliva may make it a less swelling solvent for soiled acrylic paints than pure water.

The session concluded with the instructors urging the group to try to understand the target soiling and art surface as accurately as possible, to load the range of cleaning solution choices in the direction of not swelling and not extracting material from the film, and to keep documenting findings and sharing observations.

Case studies

In the subsequent session, Bronwyn outlined a series of treatment case studies (some of which are described in *The Picture Restorer*, No.37, Autumn 2010). Here, naturally, the real world muddies the waters somewhat; issues arise of what is intentional, and the ethical stakes for the removal of original material from a painting are clearly far higher.

In one instance one might ask whether a surfactant layer might act as a buffer or release layer for dirt. Elsewhere one might be concerned that a dirty surfactant-rich layer might not only detract from the appearance of a painting but might also preferentially pick up dirt and even adversely affect the Tg or hygroscopicity of the outermost layer or the paint.

From 2006 to 2009, Axa Art Insurance sponsored the Tate Axa Art Modern Paints Project (TAAMPP) at Tate, permitting conservators to study and treat paintings by Jeremy Moon, John Hoyland, Andy Warhol, Alexander Liberman, and Bernard Cohen. Tate conservators tested a full range of wet and dry cleaning systems, and subsequent projects have enabled them to examine some of the newer cleaning materials.

Related matters including the consolidation of acrylics and a preliminary study into the issue of varnishing acrylic paintings (previously presented at the ICOM-CC Lisbon meeting) were also discussed. The challenging issue of removing applied varnishes was mentioned in connection with the thinning of a Soluvar varnish that had been unevenly applied to an Agnes Martin painting in the past.

Modular cleaning for acrylics

The case study session concluded with Chris describing the cleaning of a highly-textured painting. His account of using the Modular Cleaning Program (MCP) methodology to determine the substrate conditions and then the most suitable surfactant, chelator, pH, and conductivity formed a perfect transition into the next session.

Here, Chris discussed using the MCP program to yield a more subtle and nuanced approach to the cleaning process. He commenced with a concise account of the origins of the MCP approach in Richard's workshops, which had introduced the solvent gels that came to assert such a great impact on the field over recent decades.

Chris described the MCP principles in relation to the cleaning of acrylics, specifically the management of water with pH buffers, ionic buffers, chelators, surfactants, and gelling agents. He focused on how the system might be used to attain the objectives of managing diffusion of material into, and extraction of material out of, the paint.

He also described further the potential role of silicone based cyclomethicone microemulsions that Richard had introduced at the CAPS 2 meeting in 2011. The silicone solvents are considerably less polar than aliphatic hydrocarbons so they can be used to nudge cleaning systems further into territory that is even less likely to cause swelling of acrylics. These solvents have absolutely no surface tension, so controlling the cleaning area requires a little practice, but they do evaporate and they are clearly valuable in the clearance of microemulsions and suppressing the potential swelling of applied cleaning solutions.

Final tests and wrap-up

In the afternoon we undertook further testing on the samples and practiced cleaning with Dow microemulsions and clearing with non-polar silicone solvents. Where there were porous or vulnerable surfaces, these solvents, applied as a couch (to minimize the cleaning solution being drawn into the surface and the silicone solvent being wicked away), served to moderate the speed and extent of cleaning action of the faster-acting emulsions. On one cadmium yellow sample, the use of D4 silicone solvent to clear the microemulsion cleaning test enhanced the safe cleaning of the area even when compared with the very low aromatic content mineral spirit solvent Alcosol D40.

During these practical sessions, we also tested an additional range of microemulsions, developed by Richard, and based on differing proportions of water, the silicone solvent D4, and the surfactants laureth-3 POE (L-3) and ECOSURF™ EH-3, as well as three cleaning systems made from water, low aromatic mineral spirits, and TRITON XL-80N surfactant. (Again, see accompanying article.)

By this stage of testing, we began to be more confident in some of our observations. It was quite clear that the mixture with most water was most aggressively cleaning and swelling the paint sample. A combination of two of the microemulsions, mixed together and cleared with D4 silicone solvent, yielded the most visually pleasing cleaning result in my cadmium yellow test. However, an adjacent area of ground responded better to the TRITON XL-80N microemulsion with more water content followed by clearing with D4 silicone solvent.

We also looked at the use of cleaning components for pseudo-"controlled" swelling. In one test where swelling had locked dirt into the surface upon drying, it was possible to extract soiling with a pH 6.5 buffered Pemulen solution which enabled me to gingerly remove the locked in dirt on my sample without pulling color off (in contrast to the D40 mineral spirit in this case).

As the week drew to a close, the instructors called on the group to join the scientists in a two-way dialogue about the problems that can beset acrylic paintings and the tools and methodologies that have been developed in tandem with over a decade of research.

If we remained inexpert in the niceties of using the full range of cleaning options that were presented, the group felt we'd acquired an enhanced understanding of the material of acrylic paints and the array of research dedicated to their study. We had all gained a vivid series of haptic memories from the studio tests, as well as a new community of cohorts exploring similar issues and a methodological framework for our own explorations.

Each of us was very grateful to the instructors and to our terrific hosts including the conservation staff and the splendid Heritage Lottery Fund interns. We are also greatly endebted to Tram Vo and the GCI for preparing, organizing, and supporting the workshop.

The following reading list was given to the participants of the workshop as prepatory material.

Essential Reading for Workshop Participants

Keefe, M., C. Tucker, A. Mardilovich Behr, G. Meyers, C. Reinhardt, T. Boomgaard, C. Peitsch, B. Ormsby, A. Soldano, A. Phenix, T. Learner (2011). "Art and industry: novel approaches to the evaluation and development of cleaning systems for artists' acrylic latex paints." *Coatingstech*: 30-43.

Learner, T. and B. Ormsby (2009). "Cleaning acrylic emulsion paints: putting research into context." *Proc. of SFIIC Colloquium: Conservation-restauration des Oeuvres Comtemporaines*: 193-199

Ormsby, B. T. Learner, G. Foster, J. Druzik, and M. Schilling (2007). "Wet-cleaning acrylic emulsion paint films: an evaluation of physical, chemical, and optical changes." In *Modern Paints Uncovered*. T. Learner, P. Smithen, J. Krueger, and M. Schilling, Getty Conservation Institute, Los Angeles: 187 – 198.

Ormsby, B. and T. Learner (2009). "The effects of wet surface cleaning treatments on acrylic emulsion artists' paints: a review of recent scientific research." *Reviews in Conservation*(10): 29-41.

Ormsby, B., P. Smithen, F. Hoogland, T. Learner, and C. Miliani (2008). "A scientific evaluation of surface cleaning acrylic emulsion paintings." *15th Triennial Conference, New Delhi, 22-26 Sept. 2008: Preprints (ICOM Committee for Conservation)*. J. Bridgland. Paris, France, ICOM Committee for Conservation: 865-873.

Stavroudis, C., T. Doherty, and R. Wolbers (2005). "A new approach to cleaning I: using mixtures of concentrated stock solutions and a database to arrive at an optimal aqueous cleaning system." *Newsletter (Western Association for Art Conservation)* 27(2): 17-28.

Stavroudis, C. and T. Doherty (2010). "The Modular Cleaning Program in practice: application to acrylic paintings." *Proceedings from Cleaning 2012, New Insights into the Cleaning of Paintings.*

Wolbers, R., A. Norbutus and A. Lagalante. (2010). "Cleaning of acrylic emulsion paints: preliminary extractive studies with two commercial paint systems." *Proceedings from Cleaning 2012, New Insights into the Cleaning of Paintings*.

Optional Reading for Workshop Participants

Murray, A., C. Contreras de Berenfeld, S.Y. Sue Chang, E. Jablonski, T. Klein, M.C. Riggs, E.C. Robertson, and W.M. Anthony Tse (2002). "The condition and cleaning of acrylic emulsion paintings." *Materials Issues in Art and Archaeology VI: Symposium* held November 26-30, 2001, Boston, MA. P. Vandiver, M. Goodway, and J. Mass. Materials Research Society, Warrendale: 83-90.

Ormsby, B., E. Kampasakali, C. Miliani, and T. Learner (2009). "An FTIR-based exploration of the effects of wet cleaning treatments on artists' acrylic emulsion paint films." *e-Preservation Science* 6: 186-195.

Smith, G. (2007). "Aging characteristics of a contemporary acrylic emulsion used in artists' paints." *Modern Paints Uncovered: Proceedings from the Modern Paints Uncovered Symposium*. T. Learner, P. Smithen, J. W. Krueger, and M. R. Schilling. Getty Conservation Institute, Los Angeles: 236-246.

Smithen, P. (2007). "A history of the treatment of acrylic painting." *Modern Paints Uncovered: Proceedings from the Modern Paints Uncovered Symposium*. 165-174.

Wolbers, R. (1992). "The use of a synthetic soiling mixture as a means for evaluating the efficacy of aqueous cleaning materials on painted surfaces." *Conservation Restauration des Biens Culturels: Revue de l'ARAAFU*(4): 22-29.

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haptic - Haptic perception is the process of recognizing objects through touch. It involves a combination of somatosensory perception of patterns on the skin surface (e.g., edges, curvature, and texture) and proprioception of hand position and conformation.

The concept of haptic perception is related to the concept of extended physiological proprioception according to which, when using a tool such as a stick, perceptual experience is transparently transferred to the end of the tool.

from wikipedia